Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

L. H. Donnell, *Editor*   T. von Kármán, S. Timoshenko, *Editorial Advisers*

GENERAL

MECHANICS OF SOLIDS

MECHANICS OF FLUIDS

HEAT

MISCELLANEOUS

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Abbreviations of units follow the standard of Abbreviations for Scientific and Engineering Terms of the Am. Standards Assoc. Examples: psi (pounds per square inch); cps (cycles per second); mph (miles per hour).

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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

June 1949 Vol. 2, No. 6

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 707, 752)

692. **G. H. Handelman, "Aerodynamic pursuit curves for overhead attacks,"** *J. Franklin Inst.*, Mar. 1949, vol. 247, pp. 205–221.

This is one of a series of wartime studies directed toward the evaluation and improvement of methods of defending a bomber against fighter attacks during the bombing run. In these studies, the pursuit curves followed by fighter planes have been approximated in four different ways: (1) Pure pursuit curves are derived from kinematic considerations; the guns of the fighter are assumed to be fixed and pointed directly at the bomber and in the direction of the flight of the fighter. (2) Lead pursuit curves are obtained when the fixed guns of the fighter are assumed to be pointed ahead of the bomber by the amount (lead) necessary to score a hit; the guns are again assumed to point in the direction of flight. (3) Aerodynamic pursuit curves are derived when the angle between the velocity vector and bore axis of the gun (angle of attack) is taken into account. (4) Aerodynamic lead pursuit curves are obtained when both lead and angle of attack are considered.

The present paper is concerned chiefly with the aerodynamic pursuit curve; the further restriction of an overhead attack is included, so that the motion of the fighter is confined to the vertical plane through the straight path of the bomber. For this special case, comparisons with pure pursuit curves are made. It is shown that, whereas the pure pursuit and aerodynamic pursuit curves almost coincide, there are appreciable differences when range and bearing angles are considered as functions of time.

The paper illustrates, in a relatively simple manner, many of the major difficulties which arise when aerodynamic forces are considered. References to less restricted studies are included.

Alvin R. Eaton, Jr., USA

693. **I. I. Artobolevski and B. M. Abramov, "On the problem of motion of machines under the action of given forces"** (in Russian), *Bull. Acad. Sci. USSR Ser. tech. Sci.* (*Izv. Akad. Nauk SSSR Ser. tekh. Nauk*), Oct. 1948, no. 10, pp. 1509–1512.

Dealing with systems of one degree of freedom, the authors, without giving their reasons, introduce a new parameter which is essentially the square root of the kinetic energy. This device is used to give an unreasonably long proof of the energy equation. One of the more obvious quadrature cases is rederived. In spite of the language used, there is nothing in the paper pertaining specifically to machines.

A. W. Wundheiler, USA

694. **Raymond Chaléat, "On a device for coupling several pendulums (Sur un dispositif de couplage de plusieurs pendules),"** *C. R. Acad. Sci. Paris*, Feb. 14, 1949, vol. 228, pp. 538–540.

The author describes the following device for coupling pendulums: A pendulum P_i receives an electromagnetic impulse when the angle of the pendulum P_{i-1} is smaller than a prescribed value β_{i-1}. The problem discussed is that of synchronization and stability for the case of two pendulums.

The paper presupposes familiarity with a paper of J. Haag ["Sur la synchronisation des systèmes à plusieurs degrés de liberté," *Ann. Éc. norm. sup.*, 1947, vol. 64, pp. 285–338] whose notations and results it uses.

Z. Horák, Czechoslovakia

695. **R. C. Parker, "The frictional behaviour of engineering materials,"** *Engineering*, 1949, vol. 167: Mar. 4, pp. 193–196; Mar. 11, pp. 217–219.

This paper is essentially a practical approach to the subject of sliding or rubbing friction. The author notes that the mechanism is complex, largely unexplained, and that Amontons' (or Coulomb's) law $F = \mu N$ holds only under very restricted conditions. The temperature generated at the small areas of contact has a great effect on friction and can invalidate the results of many tests. Increase in load or velocity produces high surface temperatures which may raise or lower the friction coefficient.

The author notes that both the user and manufacturer have difficulty in evaluating frictional materials and reviews the possibilities of scaled-down tests. Data are presented showing that the effect of scaling down is often great for temperature-sensitive materials; for temperature-insensitive materials good correlation is indicated between data from two test machines differing by a scale factor of 120. Because of the variability of actual service conditions it is almost impossible properly to evaluate frictional materials whose coefficient is so sensitive. The obvious solution noted is to make and use only materials that obey Amontons' law.

This paper contains considerable experimental data substantiating the points emphasized. An appendix describes several test machines.

J. M. Robertson, USA

Theoretical and Experimental Methods

(See also Revs. 702, 706, 712)

696. **L. Hopf and Walter Nef, "Introduction to the differential equations of physics,"** Dover Publications, New York, 1948. Cloth, 6.5 × 4.2 in., 154 pp., 45 figs., $1.95.

This book gives the reader a rather quick survey of many of the types of ordinary and partial differential equations occurring in physics, together with some of the methods used in their solution. The headings of the seven chapters give a fairly good synopsis of the material covered: (I) The differential equation as an expression of a law of nature. (II) The ordinary differential equation of the mechanics of particles. (III) The simplest partial differential expressions. (IV) The simplest partial differential equations of physics. (V) Solution by eigenfunctions. (VI) Solution by change of variables. (VII) Solution by the use of singularities.

It seemed to the reviewer that the treatment of most topics is too perfunctory for the book to serve well as an introduction for a student. On the other hand an attractive feature is the insistence upon a physical or geometric interpretation of the mathematical expressions which occur. This should make the book valuable collateral reading for a student.

The translation is from volume 1070 of the well-known Sammlung Goeschen, first published in German in 1933. The publisher neglects to mention this fact. J. V. Wehausen, USA

697. M. M. Frocht, "Some simplifications in the numerical solution of Laplace's equation with special applications to photoelasticity," *Proc. Soc. exp. Stress Anal.*, 1948, vol. 6, no. 1, pp. 39–43.

This paper deals with certain improvements in the numerical solution of Laplace's equation. A simple method, which the author calls the "Linear Rosette" method, is proposed. With this method initial values may be determined rapidly. When these values are used as key values in a square, functions may be determined along complete sections.

The paper refers to the author's *Photoelasticity*, vol. II, and most of the information in the paper is included in chapter 8 of this recently published book. R. M. Wingren, USA

698. Alexander Weinstein, "On generalized potential theory and on the torsion of shafts," *Courant Anniv. Vol.*, Interscience Publishers, New York, 1948, pp. 451–460.

In this paper special cases of Beltrami's equations

$$r\frac{\partial\phi}{\partial x} = \frac{\partial\chi}{\partial y}, \quad r\frac{\partial\phi}{\partial y} = -\frac{\partial\chi}{\partial x}$$

are considered. It is pointed out that if $r = 1$ these equations correspond to the Cauchy-Riemann equations. The case $r = y^p$, $p > 0$, $y > 0$ is discussed and it is demonstrated that if p is an integer, the functions ϕ and χ are the potential and stream functions of an axially symmetric flow of an incompressible fluid in a space of $p + 2$ dimensions having the x-axis as an axis of symmetry. The case $p = 3$ is discussed and its use in the calculation of strains in the torsion problems of shafts is presented and compared to an extension of the method of sources and sinks.

Louis A. Pipes, USA

699. G. W. Stubbings, "Dimensions in engineering theory," Crosby Lockwood & Son, London, 1948. Cloth, 5 × 7.4 in., 107 pp.

This small book is one of the few works devoted entirely to the subject of dimensions and units. The treatment is elementary and, as the title implies, the book appears to have been written for the engineer and the engineering student rather than for the scientific worker. The third chapter is the most significant in the book and deals with the basic applications of dimensional analysis to the checking of formulas, deducing the nature of physical laws, and calculating conversion factors. Other chapters deal with units in general and the special problems of electrical, thermodynamical, and rotational units. John E. Goldberg, USA

700. F. Zwicky, "Morphology of aerial propulsion," *Helv. phys. Acta.*, 1948, vol. 21, no. 5, pp. 299–340.

This paper discusses and outlines the morphological method as a new approach in solving technical problems. Although, in the opinion of the reviewer, the method is not new in science, it is useful and has merit in that it first synthesizes the whole field of interest before a particular problem is selected for detailed study.

In this paper the author selects for illustrative discussion the problem of aerial propulsion and applies the method to formulating the steps required for its solution. The method is further illustrated in some detail by evaluating and comparing the performance of four types of propulsive power plants, namely: (1) the aeroduct (ramjet); (2) the aeroturbojet; (3) the aeropulse; (4) the internal-combustion engine with propeller. In discussing these four types of engines the ideal performance is derived in terms of a universal thrust formula:

$$F = M_a \Delta u + M_f u_{\text{exit}} = M u_0 \left[\beta - 1 \pm \sqrt{1 - \beta + 2\beta \Delta\epsilon/u_0^2}\right]$$

where F is the thrust, M_a and M_f the mass of air and fuel respectively flowing through the power plant per unit of time, $M = M_a + M_f$, $\beta = M_f/M$, u_0 is the velocity of the vehicle in question, u_{exit} is the average velocity of the positive jet of material expelled from the engine, $\Delta u = u_{\text{exit}} - u_0$, and, finally, $\Delta\epsilon$ is the energy available per unit mass of propellant for transformation into useful mechanical energy. The positive sign in front of the radical applies when the jet is ejected backward.

Performance curves of each power plant are derived by applying the thrust formula, using, of course, the appropriate thermodynamic efficiencies. In each instance several performance curves are plotted with β as the independent parameter, except in the case of the internal-combustion engine where the propeller diameter is chosen as the independent parameter. In the cases of the first three engines the thermodynamic cycles are given. Finally, all four power plants are compared as a function of forward speed together with the "ideal" performance curve of a power plant which transforms all of the heat of combustion of the fuel into propulsive power. F. K. Hill, USA

Gyroscopics, Governors, Servos

701. Henri Lauer, Robert Lesnick, and Leslie E. Matson, "Servomechanism fundamentals," McGraw-Hill Book Co., New York, 1947. Cloth, 9.2 × 6 in., 277 pp., 166 figs., $3.50.

This text well fulfills the authors' intention of providing an introduction to the principles underlying the theory and practice of servomechanisms. Although the mathematical and technical prerequisites for the reader are held to a minimum, an imposing amount of territory is covered. Both the engineering undergraduate and the practicing engineer will welcome this text, and will appreciate in it the careful explorations of many practical phases of servomechanism design.

For the purposes of this introductory discussion, the authors wisely restrict attention to single-loop servomechanisms and place emphasis on the transient analysis approach to the problem. This permits a clear description of the fundamental principles governing servomechanism performance. The role of transfer-function methods in the synthesis of complicated systems is then briefly explored, and the important features of the steady-oscillation techniques are discussed.

The book is divided into a number of relatively short chapters. Chapter I is a general discussion of various forms of control systems. Chapter II describes representative servosystem follow-up links. Chapter III provides a brief (and perhaps unnecessary) discussion of the fundamentals of mechanics and electricity. Chapters IV and V deal with the analysis of single-loop servomechanisms with viscous output damping and error-rate damping, respectively. A combination of the two types of damping is dealt with in chapter VI.

In chapter VII, the important problem of designing error-rate stabilization networks is considered. Chapter VIII contains an analysis of a single-loop system with integral control. In chapter IX, the transfer-function analysis of servomechanisms is discussed, and the last chapter of the book is devoted to the presentation of typical design calculations and general considerations of the problem as a whole. The style and format of the text are excellent throughout.

For the purpose for which the book is intended, namely, an in-

troduction to linear servomechanism theory and practice, the reviewer has no hesitancy in recommending it highly.

Martin Goland, USA

702. **Gordon S. Brown and Donald P. Campbell, "Principles of servomechanisms,"** John Wiley & Sons, New York, 1948. Cloth, 9.25 × 6 in., 400 pp., 207 figs., $5.

Historically, the control art is not new. The description and analysis of the stability of several types of governors or regulators were given by Sir G. B. Airy in 1840 and by J. C. Maxwell in 1868. However, the mathematical analysis of the dynamic behavior of governors, regulators, and closed-loop control systems or servomechanisms was only partially organized prior to 1940. As a consequence of the need for military security, developments in the control field were not published during the war years. Since 1945 rigorous methods of analysis and synthesis have been published. It is the object of this book to present a comprehensive treatment of closed-loop control systems and modern methods of analysis and synthesis of these systems that have been developed in recent years by many investigators.

The book is divided into eleven chapters. The first five chapters are devoted to the fundamental dynamic principles of closed-loop control systems or servomechanisms, and the transient response of servomechanisms, is studied by both classical methods and by modern operational or Laplace transform method of solving linear differential equations. The frequency or sinusoidal response of closed-loop systems is presented and the connection between the transient response and frequency response is indicated. Throughout the next five chapters, emphasis is placed on methods of scientific principles of design as well as on methods of analysis of existing systems. In the last chapter of the book, a valuable method devised by G. F. Floyd for the approximate calculation of inverse Laplace transforms is presented.

It is pointed out by the authors that the design of closed-loop systems has been frequently based on a static philosophy. This static method of design is based on analysis and leads to cut-and-try procedures for altering parts of existing mechanisms to meet varying performance criteria, and thus fails to take into account the fundamental fact that the servomechanism is a complete dynamical system. The approach to the synthesis or design problem in this book is based on the transient, and also on the sinusoidal response of the system. This point of view should be most helpful to students of servomechanism and related fields since in the usual engineering curriculum the student is asked to make isolated analyses of existing dynamical systems and, after leaving college and entering practice, the student finds that engineering involves problems in which system synthesis overshadows analysis.

The authors have introduced nondimensional variables wherever possible in order to avoid the mention of analogs and equivalents as well as to simplify the mathematics. The volume is intended for the use of both senior and graduate students. It contains numerous historical references, a collection of interesting problems, and an excellent bibliography. In the opinion of the reviewer, this book is a notable contribution to the literature of control systems.

Louis A. Pipes, USA

Vibrations, Balancing

(See also Revs. 694, 702, 719, 761, 785)

703. **H. G. Yates, "Vibration diagnosis in marine geared turbines,"** *Trans. N. E. Coast Instn. Engrs. Shipb.*, Feb. 1949, vol. 65, part 4, pp. 225–261.

As the author states, the paper deals mainly with vibrations of the forced-resonant type induced by running machinery. Fundamental properties of resonant systems are presented in a form suitable for rapid and convenient application, and emphasize the importance of determining frequency relationships with extremely high accuracy. Special instruments and techniques devised for this purpose are described, together with simpler instruments of "pocket" size. The use of these instruments and methods is illustrated by a number of examples taken from recent experience.

These examples deal with high-frequency vibrations which, though not as common, are more difficult to analyze than those of lower frequency.

Elementary reasoning supplemented by mathematical analysis indicates that vibration velocity, rather than amplitude or acceleration, is the best criterion on which to base quantitative assessments of the likelihood of mechanical failure due to vibration. This theory is presented in an appendix. Further appendixes deal in more detail with the special instruments developed for vibration diagnosis.

F. E. Reed, USA

704. **Plato, "On the damping of oscillations with weak damping arbitrarily dependent on the velocity (Über das Abklingen von Schwingungen mit schwacher in beliebiger Weise von der Geschwindigkeit abhängiger Dämpfung),"** *Z. angew. Math. Mech.*, June 1947, vol. 27, pp. 93–94.

The author (presumably not the Greek philosopher himself) derives an explicit approximate expression for the amplitude of vibration when the damping is a function of the velocity and is very weak. The converse problem is also solved, that is, knowing the decay in the amplitude, an explicit approximate expression is found for the damping law.

Edward Saibel, USA

705. **A. E. Billington, "The vibrations of stationary and rotating cantilevers with special reference to turbine blades,"** *Counc. sci. indust. Res. Div. Aero. Rep.*, no. SM.109-E.61, Jan. 1948, pp. 3–37.

A brief survey is made of methods available for the determination of the vibrating frequencies of stationary and rotating cantilevers. The relative merits of the methods are critically discussed. It is concluded that for simple cantilevers without twist, the natural frequencies are best determined from the differential equations of the system. Rayleigh's principle is useful only in the accurate calculation of the first two frequencies. Should higher frequencies be desired, the orthogonal properties of the modes may be used to advantage, with the severe limitation that in this case the fundamental mode must be accurately derived.

For beams of arbitrary twist and taper, solutions based upon the method of integral equations are strongly advocated. A discussion is given of projected methods for shortening the computations required and increasing the accuracy. The method is applied to a cantilever of arbitrary cross section in a centrifugal field, a uniform bar, and a knife-edged wedge; calculations and results for the last two cases are included.

Much space (and in the reviewer's opinion, a highly disproportionate amount relative to its importance in the actual problem involved) is devoted to the calculation of rotating frequencies.

Selwyn Gendler, USA

706. **F. Pfeiffer, "On the differential equation of transverse vibrations of a rod (Über die Differentialgleichung der transversalen Stabschwingungen),"** *Z. angew. Math. Mech.*, June 1947, vol. 27, pp. 83–91 (L. Prandtl 70th anniversary issue).

This paper analyzes the solutions of a linear homogeneous partial differential equation of the fourth order with constant coefficients. The equation is that of the transverse vibrations of a beam, given by Timoshenko [*Phil. Mag.*, 1921] and later studied

by Flügge [*Z. angew. Math. Mech.*, 1942]. The characteristic equation is biquadratic, so the characteristics in space x and time y are straight lines of slope $\pm k_1$ and $\pm k_2$. For each value of the slope, along a characteristic strip the transverse displacement and the nine space derivatives of its first-, second-, and third-order derivatives are connected by seven linear relations.

The original partial differential equation is now replaced by two simultaneous equations of the second order. We now have two new pairs of characteristic strips, still with symmetric slopes, characterized by space-derivatives of the first-order displacement-derivatives only. The constant terms of the four linear characteristics are now taken as independent variables, and the differential equations satisfied by the strips of the four types take on a relatively simple form.

Initial conditions are now assumed along the infinite x-axis (time $y = 0$) and it follows by a generalization of the classical Riemann method that the solution of the equation can be obtained in a triangle built upon an arbitrary space segment and limited by the characteristics of lesser absolute slope.

Initial conditions are next assumed along the positive half of the x-axis and time-dependent boundary conditions are assumed at $x = 0$. Hadamard's solution of the "problème mixte" is then generalized, the characteristics being reflected in the y-axis. The author points out that the errors increase with y (that is, the further down we go in time).

In the last section discontinuities in the moment and in the load are considered. It appears that the former propagate in both directions with the larger, and the latter with the lesser wave velocity.

P. LeCorbeiller, USA

Wave Motion, Impact

(See also Revs. 745, 761, 769, 789)

707. Paul Lieber and M. E. Hamilton, "On the dynamics of aircraft structures," *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1948, pp. 125–142.

Following classical lines, an approach is outlined for the determination of the loads induced in an airplane wing during landing impact. A number of restrictive assumptions with regard to the physical nature of the system considerably reduce the value of the analysis. The paper is based on work published as a company report in 1944 the later work on the subject has superseded it.

Martin Goland, USA

Elasticity Theory

(See also Revs. 716, 808)

708. Ludwig Föppl, "Drang und Zwang, Vol. III," Leibniz Verlag, Munich, 1947. Paperboard, 9.2 × 6.2 in., 191 pp., 82 figs.

This book supplements the well-known previous two volumes of the same title which were published under the joint authorship of August and Ludwig Föppl. The new third volume is devoted exclusively to the plane problem in the theory of elasticity, which had already received a more limited treatment in a chapter of vol. I.

Following an elementary exposition of the underlying theory of plane stress and plane strain, numerous classical solutions associated with the half plane, the full plane, as well as the wedge-shaped and ring-shaped region are presented. The inversion of plane stress fields is discussed in some detail, and considerable emphasis is placed on applications in curvilinear coordinates. Here several solutions of relatively recent origin have been incorporated. Although occasional use is made of complex variables, recent systematic treatments in terms of the theory of analytic functions have not been included.

This reviewer would venture the criticism that a purely two-dimensional treatment of the "plane" problem—which is in fact a three-dimensional problem—is not conducive to a full understanding of the subject. In this connection, the opening paragraph on p. 7 is particularly apt to be misinterpreted. Nevertheless, the book constitutes a valuable addition to the available literature.

E. Sternberg, USA

709. H. Parkus, "The wall-like beam on three supports (Der wandartige Träger auf drei Stützen)," *Öst. Ingen.-Arch.*, 1948, vol. 2, no. 3, pp. 185–200.

A beam rests on three equally spaced supports. The cross section is a rectangle which is very narrow, the longer edges being vertical. The length of the beam is of the same order as the height of the beam. A uniform load acts on the lower face of the beam. The problem is considered as a problem in generalized plane stress, which means that it can be reduced to the determination of a stress function F which is biharmonic in a rectangle and satisfies certain boundary conditions. The function F is determined in a standard way as an infinite series involving trigonometric and hyperbolic functions, by the use of Fourier series. Some numerical examples are presented, and the results are compared with those obtained by use of the elementary theory of bending of beams.

Courtesy of Mathematical Reviews G. E. Hay, USA

710. A. E. Green, "Three-dimensional stress systems in isotropic plates. I," *Phil. Trans. roy. Soc. Lond. Ser. A*, no. 825, Apr. 1948, vol. 240, pp. 561–597.

The considerable analytical difficulty of finding complete solutions of the elastic equations of equilibrium for plane plates has led to widespread use of the theory of generalized plane stress for the analysis of problems in which the stresses are approximately two-dimensional. In this paper a complete three-dimensional solution for a typical problem of this class is obtained in order to provide data for an accurate estimate of the validity of the generalized plane-stress theory.

The problem, selected for its physical as well as its theoretical interest, is that of the stress distribution in a plate infinitely extended in two dimensions, but of finite thickness and containing a cylindrical hole. The faces of the plate are free from stresses, and the stress distribution is assumed symmetric about the plane midway between the faces and also about a plane perpendicular to this plane.

This general analysis is used to solve the particular problem of a plate under uniform tension T in a direction parallel to its faces, the cylindrical hole being free from applied stress. Actual numerical computations are carried out for the case where the diameter of the hole is equal to the thickness of the plate, Poisson's ratio being taken as 0.25.

The calculations show that for this case the circumferential stress at the hole, averaged over the thickness, varies from a compression of $1.028T$ for $\theta = 0$ deg to a tension of $3.028T$ at $\theta = 90$ deg, as compared to values of T and $3T$ respectively from the two-dimensional theory. The average value of stress in the axial direction varies from a compression of $0.169T$ at $\theta = 0$ deg to a tension of $0.169T$ at $\theta = 90$ deg, as compared to zero axial stress assumed in two-dimensional plane-stress theory. The circumferential stress for both $\theta = 0$ deg and $\theta = 90$ deg is $0.10T$ greater at the plate center and $0.19T$ less at the plate surface than the two-dimensional result, varying approximately as the cube of the distance from the center.

S. B. Batdorf, USA

711. **Ian N. Sneddon, "Boussinesq's problem for a rigid cone,"** *Proc. Camb. phil. Soc.*, Oct. 1948, vol. 44, pp. 492–507.

The problem treated consists of the stress determination in a semi-infinite elastic medium subjected to a load applied at the surface by a rigid right circular cone whose axis is normal to the original surface of the medium.

In terms of cylindrical polar coordinates (r, θ, z) expressions for the normal stresses σ_r, σ_θ, σ_z and shear stress τ_{zr} are given which satisfy the equations of elastic equilibrium and one of the boundary conditions. These stresses are expressed in terms of the Lamé elastic constants λ and μ, the distance a from the cone axis to the edge of the pressed area, and

$$I_n^m = {}_0\int^\infty p^n f(p) e^{-p\zeta} \tau_m(p\rho) dp.$$

In this expression $\rho = r/a$, $\zeta = z/a$, and $f(p)$ is the solution of a pair of dual integral equations which, since they depend only on the surface value of the normal component of the displacement vector, are evaluated for the remaining boundary condition. Transforming from the Lamé constants to the modulus of elasticity and Poisson's ratio, the author obtains expressions for the complete determination of the elastic stresses.

The conditions of plastic flow directly under the apex of the cone and dynamical effects are discussed, but not accounted for in the foregoing equations.

Variations of the load P applied to the cone with depth of penetration are derived from a consideration of the work done. Values of P are shown to compare favorably with experimental results within a given range of penetrations depending on the apex angle.

Eben Vey, USA

712. **A. C. Stevenson, "The Dirichlet problem for a ring space,"** *Phil. Mag.*, Apr. 1948, vol. 39, pp. 297–303.

The author considers the determination of a function $\phi + i\psi$ which is analytic in a ring space S and which is such that ψ has given values on the boundary of C of S. The region S is mapped conformally onto the region between concentric circles, and the required function is then found by the use of Laurent series. As examples, there is deduced the solution to the torsion problem for a beam the cross section of which is the region bounded by (a) confocal ellipses, (b) eccentric circles.

Courtesy of Mathematical Reviews G. E. Hay, USA

Experimental Stress Analysis

(**See also Revs. 697, 728, 730, 743, 758, 807**)

713. **A. J. Durelli, "What kind of information does brittle coating give?"** *Prod. Engng.*, 1948, vol. 19: June, pp. 86–91; July, pp. 133–150.

This article presents an analysis of the crack patterns of brittle coating ("Stresscoat") with the purpose of permitting a more accurate calculation of the stresses occurring. The information given by Stresscoat consists in the directions of principal stresses (isostatics or stress trajectories) and in the isoentatics, or lines along which the principal strains are the same. The paper is based on the assumption that the elastic characteristic defining the failure of Stresscoat is the maximum tensile strain, although the author points out some exceptions to this law. By applying Mesnager's theorem and the more general Lamé-Maxwell equations several rules are given for determining the signs and the relative magnitudes of the stresses. Various zones of isostatic pattern may be distinguished. For each zone a method is presented for estimating the two principal strains ϵ_1 and ϵ_2 in plane stress, with the maximum value of the error.

The second part of the article deals with an example of the method, applied to the distribution of stresses in a ring under diametral compression. The results compare very satisfactorily with those obtained by photoelastic methods. A number of practical hints and suggestions may be useful to other workers with brittle lacquer methods.

R. G. Boiten, Holland

Rods, Beams, Shafts, Springs, Cables, etc.

(**See also Revs. 698, 709, 723, 729**)

714. **F. Salzmann, "The influence of manufacturing accuracy on additional stresses"** (in English), *Escher Wyss News*, 1946/47, vol. **20**, pp. 86–89.

The article is a discussion of the effect on stresses of slight deviations from required shape of structures caused by manufacturing processes. Calculations for bars and tubes are given, based on theory in Timoshenko's *Strength of Materials*, part II. A few data on measured deviations are given.

W. H. Hoppmann, II, USA

715. **F. K. Chang, K. E. Knudsen, and Bruce G. Johnston, "Photoelastic analysis of stresses in crane ladle hooks,"** *Iron Steel Engr.*, Jan. 1948, vol. 25, pp. 87–94.

This paper deals with photoelastic tests of five designs of ladle hooks. The authors found that the results of their tests checked well with the Winkler formula for curved beams, as modified by Dolan and Levine for cases of combined tension and bending. No systematic study of the influence of variables like the radii of fillets on the stress concentration is made. The authors recommend a reduction in cross-sectional area of the straight shanks.

A. J. Durelli, USA

716. **Carlo Minelli, "Theory of thin-walled hollow beams with diaphragms (Teoria delle travi cave diaframmate),"** Associazione Culturale Aeronautica, Rome, 1946-1948. Paper, 7.3 × 10 in., two vols. of 153 and 288 pp., 110 figs., 500 and 1200 lire respectively.

The first volume of this book gives an elementary and thorough introduction to the principle of virtual work in the study of static equilibrium, and to the principle of minimum total energy in the study of elastic systems. The fundamentals of the calculus of variations and its application to problems where a minimum is known to exist are briefly described. These principles are applied to the solution of continuous beam problems, with particular emphasis on the existence of an axis of twist and on the torsion of hollow beams.

In the second volume the theory is extended to the torsion of hollow beams with two or more vertical walls and two horizontal or slightly curved walls. The vertical walls may be thick or thin, but are stiffened by longitudinal struts so as to be treated like I-beams. The hollow beams are stiffened by transverse diaphragms variously distributed along the axis of the beam, and may have constant or variable cross sections. The treatment of these complicated structures is reduced to the standard application of a three-moment equation, in terms of which it is possible to determine the torque at any section of the beam.

The method is finally extended to beams whose lateral walls are latticed structures, or are pierced with holes, as well as to beams with diaphragms of special shape and with cantilever structures attached to them. A series of numerical problems is solved in an appendix. The beams considered are mostly wing structures, but

the theory developed in this book is applicable to many fields of structural engineering. Mario G. Salvadori, USA

Plates, Disks, Shells, Membranes

(See also Revs. 724, 725, 727, 783)

717. H. M. Sengupta, "On the bending of an elliptic plate under certain distributions of load" (in English), *Bull. Calcutta math. Soc.*, Mar. 1948, vol. 40, pp. 17–35.

The results obtained in this paper can be looked upon as a generalization of those obtained by Happel and Gosh. The former author determined the deflection of the middle surface of a thin elastic plate of elliptical shape made of isotropic elastic material, loaded at the center and clamped or supported at the edge. The second author obtained the deflection with the load placed at a focus, the edge being assumed to be clamped.

In the present paper the author studies the problem of the deflection of the middle surfaces of a thin elliptic plate under the action of a load concentrated at any point on the straight line joining the foci. The edge is assumed to be clamped. The author states in a note that he has also worked out the case when the load is placed anywhere on the upper surface of the plate.

C. B. Biezeno, Holland

718. W. Nowacki, "Bending and buckling of certain types of continuous orthotropic plates (Flexion et flambage d'un certain type de plaques continues orthotropes)" (summaries in English and German), *Publ. int. Ass. Bridge Struct. Engng.*, 1948, Third Congress, prelim. publ., pp. 519–530.

In the first portion of this paper the author studies the flexure of a continuous rectangular orthotropic plate resting on several equidistant intermediate supports parallel to two sides $y = 0$, $y = b$, for various edge conditions and under uniformly distributed lateral loads for each bay (which may be of different magnitudes for different bays). The author then studies the buckling of such a continuous plate under the action of compression forces in its middle plane applied to the two sides $x = 0$, $x = a$. In the latter study the edges of the plate are taken as simply supported. Henry Favre, Switzerland

719. Osvaldo Zanaboni, "The rectangular plate supported on two opposite sides, and under various edge conditions on the other two (Lastra rettangolare appoggiata su due lati opposti e soggetta a condizioni statiche varie sugli altri due)," *G. Gen. civ.*, Mar.-Apr. 1948, vol. 87, pp. 138–148.

A thin rectangular plate is simply supported along the edges $x = 0, h$, and is loaded by arbitrary lateral forces. A procedure for deriving the lateral deflection $w(x, y)$ is described for various boundary conditions along the remaining two edges $y = a_1, a_2$, on the assumption that the edge conditions can be satisfied in accordance with the Kirchhoff thin-plate theory.

The deflection is computed as the sum of two terms $w_0 + \bar{w}$, where w_0 is computed from the external loads by a procedure given previously by the author [*Ann. Mat. pura appl.*, 1940 and 1941; *Ric. Ingeg.*, 1941, nos. 4, 5]. The procedure for computing the correction term $\bar{w}$ is given in the present paper for the following edge conditions specified along $y = a_1, a_2$: (*a*) deflection and slope; (*b*) deflection and bending moment; (*c*) deflection and shear; (*d*) slope and bending moment. The correction term is designed to correct for the effect of the linear interpolation between adjacent stations along the beam which was assumed in the previous solution. It is shown that with this correction term the procedure leads to a value for the fundamental frequency of a uniform cantilever beam which is correct within less than 0.1 per cent, assuming only five stations along the beam and carrying out only one cycle of computation. The procedure can be extended to compute the higher-frequency modes by sweeping out the known lower-frequency modes with the help of the orthogonality relations. Walter Ramberg, USA

720. A. Weinstein and J. A. Jenkins, "On a boundary value problem for a clamped plate," *Trans. roy. Soc. Can. Sec. 3*, May 1946 (published in 1947), ser. 3, vol. 40, pp. 59–67.

In a previous paper [*Amer. J. Math.*, 1942, vol. 64, p. 623] Aronszajn and Weinstein have shown that problems involving the small deflections of a clamped plate can be reduced to the determination of a function $w(x, y)$ which minimizes the integral

$$J = \int\int [(\Delta w)^2 - 2qw]\, dx\, dy$$

and satisfies the conditions $w = 0$, $dw/dn = 0$ on C, where Δ denotes the Laplacian operator, q is a given function describing the load on the plate, S is the region occupied by the middle plane of the plate, C is the curve bounding S, and dw/dn is the derivative in the direction of the outer normal to C. This variational problem is denoted by VP.

In the present paper it is shown that VP is the limit of a sequence of variational problems. The first member of this sequence is just VP with the second boundary condition removed. The remaining members of this sequence are just VP with the second boundary condition replaced by a condition which becomes successively stronger. G. E. Hay, USA

721. M. M. Filoneko-Borodich, "The bending of a rectangular plate with two clamped opposite edges" (in Russian with English summary), *Vestnik Moskov. Univ.*, 1947, no. 3, pp. 29–36.

This is a sequel to a previous paper of the author's in which the system of "almost orthogonal functions"

$$P_n(x) = \cos\frac{n\pi x}{a} - \cos\frac{(n+2)\pi x}{a},\ n = 0, 1, 2, \ldots,$$

is applied to solve approximately the problem of deflection of a thin elastic rectangular plate clamped along the edges $x = 0$, $x = a$, and with arbitrarily prescribed boundary conditions along $y = 0$ and $y = b$. The normal load $q(x, y)$ is symmetric with respect to the line $x = a/2$. The approximate deflection w is sought in the form $w = \Sigma_{m=0}^{n} P_{2m}f_{2m}(y)$ where the functions $f_{2m}(y)$ satisfy the system of fourth-order differential equations arising from the deflection equation $D\nabla^4 W = q(x, y)$. The solution for a rectangular plate clamped along all four edges is indicated.

I. S. Sokolnikoff, USA

722. S. G. Lekhnitsky, "Anisotropic plates" (in Russian), OGIZ, Moscow, 1947. Cloth, 8 × 5.2 in., 354 pp., 145 figs.

This is a new edition of a book (first published in 1944) concerned with a systematic treatment of the theory of thin anisotropic elastic plates subjected to small deformations. Its object is to acquaint those working with anisotropic mediums with the present state of development of a branch of elasticity which is assuming great technical importance. The book develops three basic themes: (1) The state of generalized plane stress in anisotropic mediums, chapters 1-7, 138 pp. (2) Small deflections of thin anisotropic plates, chapters 8-11, 138 pp. (3) Stability of thin anisotropic plates, chapters 12-15, 102 pp.

The presentation is condensed and the stress is placed on the practical side of the theory in order to make the book serve as a

guide to designers of structures built of anisotropic materials. Many conclusions are summarized in the form of graphs and tables. The theoretical results are often stated without proofs, with an indication of sources where proofs may be found. Bibliographical references include 80 items, with the latest entry dated 1943. This is the first comprehensive exposition of anisotropic theory of elasticity in book form known to the reviewer.

I. S. Sokolnikoff, USA

Buckling Problems

(See also Rev. 718)

723. **George Winter, "Performance of thin steel compression flanges"** (in English with summaries in French and German), *Publ. int. Ass. Bridge Struct. Engng.*, 1948, Third Congress, prelim. publ., pp. 137–148.

This is a report of the most recent of more than 100 tests to determine the effective width at ultimate and at design loads of compressed rectangular plates under the conditions holding when they act as webs of thin-walled I-, channel-, and other beam sections. Earlier tests have been previously reported [*Proc. Amer. Soc. civ. Engrs.*, 1946, vol. 72, p. 199, and *Trans. Amer. Soc. civ. Engrs.*, 1947, vol. 112, p. 1].

The results are expressed as a modification of von Kármán's formula for ultimate buckling strength and plotted. The plates in the present tests are loaded as compression elements when the beam is under pure bending.

The effective widths determined for 15 beams are used to compute yield loads, which are compared with observed values. The greatest deviation is 14 per cent, the average 0.7 per cent. Deflections computed for yield loads and divided by 1.85 show a greatest deviation of −20.5 per cent (computed deflection larger than observed) and an average deviation of −5.2 per cent. If the full, rather than the effective, width is used, these deviations are 54 per cent and 23.3 per cent (computed deflection smaller than observed).

In the interest of simplicity the variation of effective width (due to variation of moment) in the end parts of the beam not under pure bending was not included, only the minimum effective width being used. The author concludes that the method allows prediction of carrying capacity and deflection with reasonable accuracy, the accuracy being necessarily less than for the usual rolled sections. Distortion of section shape due to stress and curvature is briefly discussed.

J. N. Goodier, USA

724. **F. J. Plantema, "Some investigations on the Euler instability of flat sandwich plates with simply-supported edges"** (in English), *Nat. LuchtLab. Amsterdam Rap.*, no. S.337, June 1948, 13 pp.

Several mathematical studies of the buckling of elastic sandwich panels are summarized in this report. All of the investigations were performed by the Nationaal Luchtvaartlaboratorium of Amsterdam in the years 1943 to 1948, and details of the work are given in other reports of that institution. The analyses treat rectangular elastic sandwich panels with simply supported edges that are subjected to uniformly distributed shear forces and compression forces in the planes of the panels. The cores and the cover plates are considered to be isotropic in their planes. Crippling of the cover plates is not considered.

Van der Neut sought to determine the buckling loads as eigenvalues of a differential equation. In deriving the differential equation, he employed several reasonable approximations. Van Wijngaarden eliminated some of the approximations of Van der Neut's theory, but retained the assumption that the core carries no load. Both theories take account of shear deformation of the cores. The eigenvalue problems were found to be readily solvable in cases of biaxial compression, but characteristic difficulties were encountered in cases for which the shear loads were not zero.

The present author treats the problem by means of the energy theory of elastic stability. The total deflection due to buckling is split into a shear component and a bending component. The energy due to stretching of the middle plane of a cover plate is assumed to be determined by the bending deflection; the energy due to bending of a cover plate by the total deflection; the energy due to bending of the core by the bending deflection; and the energy due to shear deformation of the core by the shear deflection only. The energy theory is found to agree substantially with the theories of Van der Neut and Van Wijngaarden in cases of pure biaxial compression. For problems of shear buckling, the energy theory is considered to be preferable, since it is well adapted to approximation procedures based upon assumed deflection patterns.

H. L. Langhaar, USA

725. **H. L. Cox and E. Pribram, "The elements of the buckling of curved plates,"** *J. roy. aero. Soc.*, Sept. 1948, vol. 52, pp. 551–565.

Behaviors of curved plates under axial compression are reexamined by an approximate analysis in which the detail shape of the buckled form is ignored and the strain energy is expressed in terms of the wave amplitude and the wave length only. A parabolic relation is found to exist between the average axial stress and the end shortening (the author uses the term "edge stress") after a critical buckling stress has been exceeded. This parabola is tangent to the load deflection curve before buckling at the buckling point.

The critical buckling stress for a curved plate is obtained by providing for a smooth transition from the flat plate to a complete cylinder. An empirical formula is suggested whereby the number of half waves across the width b of the plate may be computed for any arbitrary camber parameter (b^2/Rt). The upper limit of this parameter is taken as 78.

Postbuckling behaviors of curved plates with b^2/Rt varying between 0 and 78 are treated by an arbitrary variation of two coefficients which define the shape of the parabola, more or less in line with the experimental evidence available. The effect of initial irregularities is shown to be important for the peak value of the average axial stress, which in part explains the wide scatter of the experimental results.

Although the treatment of the postbuckling phenomenon is very approximate in nature and involves much empirical adjustment the authors are able to establish good agreement between their results and measured minimum postbuckling axial stresses.

Conrad C. Wan, USA

726. **F. J. Plantema, "Collapsing stresses of circular cylinders and round tubes"** (in English), *Nat. LuchtLab. Amsterdam Rap.*, no. S.280, 1947, pp. 1–36.

Nondimensional diagrams or formulas are given in this paper for determining the buckling stresses of thin circular cylinders and thick-walled round tubes under compression, bending, torsion, shear and combined loadings such as: bending and compression; compression, bending, and torsion; bending with transverse load; bending with transverse load and torsion. Thick-walled tubes are defined as tubes in which local instability will occur only in the plastic region. The coordinates used in the diagrams or the general forms of the formulas follow theoretical considerations, while the diagrams themselves or the coefficients of the

formulas are determined from a critical examination of the experimental data available in the literature. C. T. Wang, USA

727. B. Budiansky, M. Stein, and A. C. Gilbert, "Buckling of a long square tube in torsion and compression," *Nat. adv. Comm. Aero. tech. Note*, no. 1751, Nov. 1948, pp. 1–17.

The buckling of the sides of an infinitely long square tube under combined axial compression and torsion is investigated by the energy method, and an interaction curve is obtained giving the amount of one loading required to produce buckling when a given amount of the other is present. Two forms of buckling are considered. The first, involving rectilinear nodal lines which break the panels up into squares, occurs when only small amounts of shear stress are present. In the second pattern, which occurs for larger proportions of shear stress, the transverse nodal lines progress around the tube in a helix-like manner.

Assuming the deflection to be given by Fourier series, the energy is expressed in terms of the Fourier coefficients, to which are added two additional series involving Lagrangian multipliers to satisfy the assumption of zero deflection at the corners of the tube. Minimizing this function with respect to the Fourier coefficients yields two equations which lead to a buckling criterion expressed as a series involving the two loadings and the mode of buckling. For given values of one stress and wave-length ratio the critical value of the remaining loading may be calculated. This procedure is repeated for various wave-length ratios until the minimum stress is obtained. John E. Goldberg, USA

Joints and Joining Methods

(See also Revs. 729, 750, 755)

728. Karl L. Zeyen and Wilhelm Lohmann, "Welding of ferrous metals (Schweissen der Eisenwerkstoffe)," Verlag Stahleisen m.b.H., Düsseldorf, 1948. Paper, 9 × 6.2 in., 456 pp., 304 figs.

In the first section the authors discuss various welding processes, ranging from forging to arc, atomic hydrogen and union melt welding. The second section deals in detail with materials used for welding, and the effect of welding on them and on the base metals. This section is richly illustrated with macro- and microphotographs. In the third section the authors discuss the susceptibility of weldments to cracking, and distinguish between intercrystalline cracks, mostly along grain boundaries, and intracrystalline cracks which generally pass through grains. They discuss the influence of composition, and methods of measuring susceptibility to weld cracking.

The fourth section deals with welding techniques, including heat-treatments for improving welds and a comparison of the strength of filled and *V*- or *X*- butt welds. In the fifth section, the authors discuss shrinkage stresses due to welds, including methods of measuring such stresses and of reducing them (by proper design or by heat-treatment, hammering or stretching after welding). The sixth section deals with tests of welded connections. These include tests for tensile strength and the German standards for tensile specimens, tests for measuring the ductility of welds (by notched-bar impact, by bending of butt-welded plates, and tensile tests of a specimen made of two lengthwise butt-welded strips) and numerous other tests. A discussion of test results is also given.

The remainder of the book is concerned with the economics of welding and various industrial applications, flame cutting, soldering and flame hardening, and training and accident prevention. A very extensive bibliography is appended. F. Hymans, USA

Structures

(See also Revs. 716, 802, 803, 804, 805)

729. A. Schwertner, "Continuous or coupled frames" (in Hungarian), *Publ. tech. Univ. Budapest* (*Müegyetemi Közl.*), 1948, no. 1, pp. 89–114.

An analytical method is given which permits the stress calculation of systems consisting of a series of curved frames with variable cross-sectional areas. The method takes into consideration the elastic deformation of the points of interconnection or support of these frames. This is a novel application of the standard analysis for restrained single arches which was first suggested in 1884 by Mueller-Breslau; in this analysis the three unknowns are assumed to be acting at the "elastic center" of the arch, so selected that the deformations which would interconnect the three unknowns become zero, thus allowing the solution of the problem by three independent equations, one for each of the unknowns.

Expanding on this principle, it is shown that a system of continuous or otherwise coupled frames can be analyzed by expressing each unknown by a sum of quantities each of which can again be obtained from one independent equation. General equations relating to various frame configurations are derived in detail. No numerical examples are given.

Karl Arnstein, USA

730. H. A. Wills, "The life of aircraft structures," *J. Instn Engrs. Austral.*, Oct. 1948, vol. 20, pp. 145–156.

This is a clear, fairly exhaustive account of present knowledge of life expectancy and related problems. The author first summarizes causes tending to a shorter fatigue life of modern airplane structures, namely: (*a*) design refinement and reduction of load factors; (*b*) increase of cruising speed; (*c*) increase of size, which reduces the resonant frequency; (*d*) use of stronger materials which are more notch sensitive.

A description is given of instruments used for measuring the accelerations and hence loads experienced by aircraft in flight. Then follows a discussion of the influence of the chief design variables, aspect ratio, wing loading and cruising speed on the loads arising from gusts. The strain counter, an electronic device developed by the CSIR Division of Aeronautics, is described. This counts the number of times the strain exceeds a series of specified values at a given point of the structure. The response of a large aircraft to dynamic loads is very complex and the strain counter may be very useful in its investigation. In the discussion of the effect of fluctuating loads on the structure a method proposed by H. A. Wills is given for constructing the S-N curve for any given load range $R=$(min stress/max stress) from the S-N curve of the symmetric cycle ($R=-1$).

A numerical example of life estimation is given. The chief assumptions made are: (1) the load fluctuations are caused entirely by gusts; (2) positive and negative gusts occur in pairs of equal magnitude; (3) gusty conditions persist for one tenth of the total flying time; (4) gusts are fully effective in producing loads on the structure; (5) the fraction of the total available life consumed by gusts of a given magnitude is the ratio of the number of gusts of that magnitude to the number of cycles to failure at the corresponding load range; (6) the decisive part of the structure and its endurance data are known. With regard to points (4) and (6) the author emphasizes that extensive experimental investigations must be undertaken, involving studies of the strains induced in the wing structure at various points, their relation to the accelerations of the aircraft, and the fatigue characteristics of aircraft structures.

The author does not discuss the intersect method for the predic-

tion of fatigue life under the action of random stress fluctuations (reference 1 of his paper). The effect of stress concentrations might have been discussed in greater detail; in the references no mention is made of the work of E. C. Hartman ["Fatigue test results. Their use in design calculations," *Prod. Engng.*, Feb. 1941]. M. M. Gololobov, Czechoslovakia

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 745, 746, 749, 801)

731. **L. N. Kachanov, N. M. Belyaev, A. A. Ilyushin, W. Mostow, and A. N. Gleyzal, "Plastic deformation,"** Mapleton House, Brooklyn, 1948. Cloth, 8.5 × 5.5 in., 192 pp., 39 figs, $8.

This small book of 192 pages of photographically reduced typewritten pages, edited by Henry H. Hausner, is a collection of seven papers, of which the first five are translations of papers originally published in journals in the USSR by Russian authors. The translations were made by Brown University. The collection is prefaced by a one-page "Introduction" by the editor.

The first two papers, "On the mechanics of plastic solids" (7 pp.), by L. N. Kachanov, and "Theories of plastic deformation" (32 pp.), by N. M. Belyaev, contain a review of the theories of plastic deformation. Parts of the contents of these two papers and other chapters in the book overlap and are repetitions of each other. They reproduce the equations on which the theory of plastic deformation has been based since the times of de St. Venant, referring to papers by von Mises, Hencky, Prandtl-Reuss and others. Belyaev (chapter 2), when interpreting the equations by Reuss in their relation to those of Hencky, considering in both cases the sum of small elastic and permanent strains, overlooks the principal difference in their postulates, namely that those by Reuss permit a rotation of the principal directions of stress relative to the body, while those of Hencky do not consider a rotation as permissible. The author's statements thus convey only a superficial picture of the essential facts brought out by the various theories he discusses or compares.

In the Introduction (p. 5), one reads in this connection: "A new theory for plastic deformation is developed by N. M. Belyaev in chapter 2. It is a well-known fact that the classical theories of elasticity are no longer considered adequate for the application to certain problems, especially those of structural stability. N. M. Belyaev's new theory makes it possible to predict stresses and deformations in the plastic range." A check on the content of the paper discloses that this statement grossly exaggerates the facts, and this should not be permitted to pass unnoticed. The paper by Belyaev contains essentially little in the way of new advances in the theory. It is mainly a review of existing theories which were well-known at the time the paper was written in 1937. Belyaev describes in it among other subjects the theory of plastic torsion of a round bar for a strain-hardening metal, which had been well-known in 1937 for many years; the experiments on torsion reported in this paper seem also to be of no great importance. His paper contains a brief reference to the torsion of the plastic cylinder of elliptic cross section which may have been new at that time.

Chapters 3 to 5 are translations in abbreviated form of three important papers by A. A. Ilyushin entitled "Some problems in the theory of plastic deformations" (42 pp.), "Relation between the theory of Saint Venant-Levy-Mises and the theory of small elastic-plastic deformations" (20 pp.), and "The theory for small elastic-plastic deformations" (20 pp). Although these papers also review the theories of plasticity they contain a number of important new advances and developments in the theories; for example, in the treatment of elastic-plastic cases of bending of thin flat plates and of the bending and uniform straining of axially symmetric cases of plastic cylindrical shells. From the first-mentioned paper by Ilyushin may be quoted the following theorems: "The components of the stress deviation have a potential which depends only upon the intensity of deformation." "For an active elastic-plastic process, the internal work done per unit volume of a body is a function only of the strain intensity and the increase in volume." "For an active, simple deformation process, in the absence of body forces, of all kinematically possible deformations which assume the specified displacements on the boundary, the one that actually takes place is that which minimizes the work done by the internal forces." "If a body undergoes an active simple deformation then the variation of the total work of the internal forces equals the work done by the external forces on the variations of the body displacements." There are a number of interesting side remarks in all three papers by Ilyushin. He distinguishes a theory of plasticity in which the components of stress are related to the components of total strain (the sums of the elastic and of the permanent parts of the components of strain), from the theory in its original form as suggested by de St. Venant in which the components of the rates of strain are related to the components of stress.

In chapter 6 Wolfe Mostow reports on "Plastic deformation of thin plates under hydrostatic pressure" (24 pp.). The title may be misleading, since the author considers only the membrane stresses in thin metal diaphragms under lateral load during their plastic bulging. This work was done in the United States under government support. The author uses the true principal components of stress and the components of the natural strains (considering strains of finite magnitude). One of his principal equations on which he bases his computation is applied to a case for which it is not valid for the natural strain components. This refers to his equation expressing the equality of the three proportions containing the differences of the principal stresses in the numerator and the differences of the natural principal strains in the denominator. These three equalities are only valid under certain restrictions, but the author has apparently not been aware of this. In attempting to find workable solutions Mostow assumes for the stress-strain curve a power function for the stress as a function of the permanent strain, stating "it has been observed by a great many investigators that a very good fit to the tensile stress-strain diagram is given by the empirical expression $\sigma = C\epsilon^n$," a statement which must be questioned if one thinks of mild steel. The author deals with the bulging of circular and rectangular membranes of this metal.

In chapter 7 A. N. Gleyzal reports on "Plastic deformation of a thin circular plate under pressure" (29 pp.). A review of this valuable paper may be omitted since this paper has meanwhile been published in the *Journal of Applied Mechanics* as one of the papers presented during the ASME Symposium on Flow and Fracture of Metals, 1947 [see Rev. 26, Jan. 1949].

The title on the cover of the book is misleading, in that only one author's name, namely that of N. L. Kachanov, appears on the cover, in a collection of articles by a number of authors in which the article by Kachanov consists of only 7 pp. out of 192 pp.! The prefacing Introduction as well as other parts of the book contain many misprints. On p. 16 the text states that differentiation with respect to the time will be denoted by placing a dot above the corresponding strain symbols, but no dots appear where they should be placed above symbols. Several sentences on pp. 16 and 17 are entirely meaningless, apparently as the result of negligent typing of entire sentences and paragraphs. One must wonder that the text of a book could be published with so many typographical errors. Poisson's ratio in the first chapter is denoted by ν, in chapter 2 by μ. Many of the mathematical symbols in the book are poorly written or typed, not to speak of

the mathematical symbols which have been changed in an arbitrary way, without giving any consideration to the accepted and established standards used in mechanics in the United States. One is tempted to ask whether the reproduction of such a text could not have been inspected or revised with a little care before it was released in book form. In general it may be somewhat questioned, with due respect to the work of certain outstanding recent authors in Russia, among whom Ilyushin justly deserves to be favored with translations of his outstanding investigations in the theory of plasticity, whether the other Russian papers by Kachanov and Belyaev included in this collection were worth being published in English translations.

A. Nádái, USA

732. E. A. Davis, "A generalized deformation law," *J. appl. Mech.*, Sept. 1948, vol. 15, pp. 237–240.

Assuming that the octahedral shearing stress is a known function of the octahedral shearing strain (independent of stress state) and that $\mu = (2\sigma_2 - \sigma_3 - \sigma_1)/(\sigma_1 - \sigma_3)$ is a similar function of $\nu' = (2\epsilon_2 - \epsilon_3 - \epsilon_1)/(\epsilon_1 - \epsilon_3)$, the principal natural plastic strains ϵ_1, ϵ_2 and ϵ_3, if they are small, may be determined directly from the principal stresses corresponding to any stress state, and from the following equations which are derived in the paper: $\epsilon_1/(3 - f) = \epsilon_2/(2f) = \epsilon_3/(3 + f) = F(24 + 8f^2)^{-1/2}$. Here F is the octahedral shearing strain corresponding to the octahedral shearing stress for the stress state considered and f is the value of ν' corresponding to the μ for the stress state considered.

J. D. Lubahn, USA

733. A. A. Ilyushin, "The theory of plasticity in the case of simple loading accompanied by strain-hardening," *Nat. adv. Comm. Aero. tech. Memo.*, no. 1207, Feb. 1949, pp. 1–7 (transl. from *Prikl. Mat. Mekh.*, vol. 11, no. 2, 1947).

The loading of an element of a strain-hardening material is said to be simple when the stress is applied so that the principal axes do not vary relative to the element and the principal stress components increase in strict proportion. It is shown that theories of plasticity which differ for general loading may nevertheless predict the same deformation for a simple loading; this is true, in particular, for the physically contrasting theories of the Reuss and Hencky types.

Rodney Hill, England

734. Rudolf Böklen and Richard Glocker, "Mechanical and X-ray examination of plastic flow during bending (Röntgenographische und mechanische Untersuchung des Fliessvorganges bei Biegung)," *Metallforsch.*, Oct. 1947, vol. 38, pp. 304–309.

Bending tests were made on square rods of a chrome-molybdenum steel whose stress-strain diagram practically coincided with that of an ideal plastic material. The deformations were determined mechanically and by X rays. Tests and theory agreed very well.

K. W. Johansen, Denmark

735. Lawrence Bragg, "The yield point of a metal," *Rep. Conf. Strength Solids Univ. Bristol*, July 1947 (publ. in 1948), Physical Society, London, pp. 26–29.

A criterion for determining the strain at which a metal will yield, which was first proposed by the author in 1942 [*Nature Lond.*, vol. 149, p. 511], is extended. It is assumed that yield occurs when the applied strain becomes so large that the energy of a small region will be decreased as a result of slip by one atomic distance across one of the slip planes of the small region or "crystallite." It is not required that energy be released for each infinitesimal unit of slip, as is normally assumed in discussions based upon the theory of dislocations, but only that there be a decrease of energy after slip by one interatomic distance has occurred across the entire slip plane within the "element of the crystal" (which is regarded as a natural unit, and the dimensions of which are not precisely known).

In the former paper the author was able to analyze his criterion only in a relatively qualitative manner. Since then, however, W. R. Dean, A. H. Wilson, and E. H. Mann have carried out calculations of the variation of the energy of an isotropic medium under shearing stress if slip is allowed to occur in a planar strip joining two parallel lines which are in the plane of shear and extend in a direction normal to the direction of shear.

The author does not attempt to specify the spacing between the two lines on the basis of first principles, but leaves this as a parameter to be determined by comparison with experiment. This spacing should correspond to the average linear dimension of the above "element of the crystal." Experiment indicates that the yield point in pure cold-worked copper occurs when the angle of shear is 12 min of arc. Using this value of the yield strain, it is found that energy is gained in the element of the crystal when one atomic unit of slip occurs, provided that the slip extends for a distance of about 1000 interatomic distances in the direction of shear. It is proposed that the techniques of modern physics be employed to determine this distance by other means and hence provide a check on the present theory.

Frederick Seitz, USA

736. Lawrence Bragg, "Effects associated with stresses on a microscopic scale," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 221–226.

A formula is established by the author for the elastic limit of strain γ, in pure metals. It is based on the assumption that slip will occur if it will result in a diminution of energy. Dislocations are supposed to be present always to overcome the high energy barrier, thermal fluctuations not being able to trigger the process. An experiment on bubbles under shear is shown which, although admitted to be an imperfect representation of a metal, gives an elastic strain limit of about s/t as would be expected for metals, where s is the quantum of slip (one atomic distance) and t the dimension of the perfect crystallite. Dean and Mann's energy calculation for a plate of isotropic metal with a slit of length t subject to a simple shear γ parallel to the slit is quoted. Holes are assumed at the ends of the slit to limit the strain energy to that required for melting. This leads to a limiting value of γ of 5.5 s/t.

D. C. Drucker, USA

737. R. D. Heidenreich and W. Shockley, "Study of slip in aluminum crystals by electron microscope and electron diffraction methods," *Rep. Conf. Strength Solids Univ. Bristol*, July 1947 (publ. in 1948), Physical Society, London, pp. 57–74.

The electron microscope has been used to show the manner in which slip occurs in a slip band. It was found that the slip band is not a region of uniform shearing strain, but that it is made up of small slip laminae. The thickness of one lamina or interslip region is about 200 A, and the maximum relative displacement of adjacent laminae is about 2000 A. The authors believe that the slip band starts as a single step or slip of about 2000 A, and that the number of laminae increases as the deformation increases. Electron diffraction photographs have been used to show that adjacent interslip regions rotate somewhat with respect to each other. The actual rotation occurs in the laminar slip bands and the rotation is about the normal to the slip planes.

The authors found, as had been previously reported by Wood, that single crystals subject to a static tensile stress less than the

yield value could be hardened by superimposing an intermittent or pulsating stress. This hardening was accomplished without producing any slip lines that could be detected by the electron microscope. The hardening was evidenced by the disappearance of Kikuchi lines in the electron diffraction-reflection patterns. It is suggested that this hardening is due to the generation of dislocations at the surface of the crystals.

The authors do not attempt to explain why the interslip regions should have a thickness of about 200 A, and for this they may very well be excused. They do, however, surmise that the relative displacement of adjacent interslip regions may be limited to about 2000 A by fragmentation and disorientation of the material in the interslip region. A discussion of the foregoing findings in terms of "dislocation" theory is included in an appendix.

Evan A. Davis, USA

738. D. J. McAdam, Jr., G. W. Geil, K. H. Woodard, and W. D. Jenkins, "Influence of size and the stress system on the flow stress and fracture stress of metals," *Metals Technol.*, June 1948, vol. 15, T. P. no. 2373, 19 pp.

In previous papers the authors and their collaborators have shown that the "technical cohesive strength" is a function of all three principal stresses and depends on these and on plastic deformation, strain rate and temperature qualitatively in the same manner as does the flow stress. The influence of the stress system was studied by means of tension tests of notched specimens in which the minimum cross section is under transverse tension. This transverse stress increases with the depth and sharpness of the notch. It was shown that the fracture stress increases with increase of the "stress ratio" (transverse stress to longitudinal stress).

However, Fisher and Holloman, in a recently published statistical theory of fracture [*Metals Technol.*, Aug. 1947; *Trans. Amer. Inst. min. metall. Engrs.*, vol. 171] based on the theory of Griffith, obtained the result that the fracture stress decreases in the presence of two equal transverse tension stresses, in disagreement with the above conclusions. Fisher and Holloman attribute the observed increase of the fracture stress with the depth and the sharpness of a notch to the corresponding decrease in the volume in which fracture can occur.

The authors of the present paper describe tensile tests with unnotched and notched specimens of a mild steel and of oxygen-free copper. Not only the depth and sharpness of the notches but also the general dimensions of the specimens were varied over a large range, so that both the stress ratio and the volume size varied widely. The results obtained show that at a constant stress ratio the volume size has practically no influence on the fracture stress and the ductility, but at a constant volume size the fracture stress increases considerably with the sharpness of the notches, in accordance with the authors' previous findings. They conclude that the statistical theory is only applicable to the fracture of brittle materials (and then is in fair agreement with the experiments) but not to the fracture of ductile materials, even after a slight plastic deformation, because such a deformation levels out the local stress concentrations. Albert Kochendörfer, Germany

739. J. M. Burgers, "Non-linear relations between viscous stresses and instantaneous rate of deformation as a consequence of slow relaxation" (in English), *Proc. kon. Ned. Akad. Wet.*, Sept. 1948, vol. 51, pp. 787–792.

The author studies a problem treated by Weissenberg ["A continuum theory of rheological phenomena," *Nature Lond.*, 1947, vol. 159, p. 310] referring to the stresses produced by deformation in viscoelastic materials, where laminar flow is accompanied by elastic deformations. It is pointed out that when the relaxation time of the material is large, the physical deformation is no longer proportional to the instantaneous rate of deformation, and the tensor describing this deformation will no longer have the same principal axes and proportional principal values as the tensor of instantaneous rate of deformation. In addition, account must be taken of large deformations.

It is demonstrated, in particular, that in the case of laminar flow under these conditions, a tensile stress in the direction of flow must be superposed on the usual system of shearing stresses.

G. H. Handelman, USA

Failure, Mechanics of Solid State

(See also Revs. 730, 735, 736, 738, 744, 749, 752, 799)

740. P. E. Shearin, A. E. Ruark, and R. M. Trimble, "Size effects in steels and other metals," *Rep. Conf. Strength Solids Univ. Bristol*, July 1947 (published in 1948), Physical Society, London, pp. 158–162.

The authors present the results of notch-bend tests on geometrically similar specimens cut from a 2.5-in. plate of Ni-Cr steel, with nine different heat-treatments. The work per unit volume required for failure was found to decrease markedly with increase of size, for all the heat-treatments. The authors present a brief explanation which seems plausible but should be examined further in the light of data from other sources. This is a challenging paper, and creates a desire to see more data, particularly with regard to the comparison discussed between the effects of size in the notch-bend test and in an ordinary tensile test.

R. G. Sturm, USA

741. Erich Siebel and Max Pfender, "Further developments in strength calculations for alternating stresses (Weiterentwicklung der Festigkeitsrechnung bei Wechselbeanspruchung)," *Stahl Eisen*, Sept. 11, 1947, vol. 66/67, pp. 318–321.

If the dependence of fatigue strength on stress variations in the most highly stressed outer fibers can be generalized for asymmetric stresses, simple bending-fatigue tests and notch-fatigue tests, for example, will be merely special cases of the same general law. This article discusses and presents experimental evidence in support of a new fatigue-strength theory based on "relative stress gradient" $\chi = (1/\sigma)\, d\sigma/dx$, where $d\sigma/dx$ is the stress gradient.

The influence of χ on the fatigue strength of a material is determined from bending tests on specimens of different diameters and is expressed in the form of a curve. From this a calculation of fatigue strength for any stress distribution can be carried out so that the actual stress at the most highly stressed point will remain with sufficient certainty below a predetermined value, which will be indicated by χ and a form factor.

Fatigue tests with notched specimens correlate well with tests of unnotched samples. Bending-fatigue tests with χ varying from 0.3 to 2.0 mm^{-1} show that fatigue strength remains nearly constant with variations of χ when χ is above 1.0 mm^{-1}.

W. C. Johnson, Jr., USA

742. P. H. Frith, "Fatigue tests on crankshaft steels," *J. Iron Steel Inst.*, Aug. 1948, vol. 159, pp. 385–409.

Combined stress-fatigue tests (combinations of reversed bending and torsion) were made on solid specimens 0.6-in. diam machined from heat-treated Cr-Mo steel and nitrided for 10 to 72 hr at 485 C. The fractures all started near the junction between case and core. The author calculates that, in spite of the different thicknesses of the case (from 0.016 to 0.026 in.), the

maximum shear stresses at this junction at fracture were all about the same, 8.8 per cent above the fatigue limit of unnitrided specimens. Assuming the same case thicknesses for a 3-in-diam solid shaft without stress concentrations (the author neglects possible scale effect) the author calculates that the fatigue limit would be reduced only 0.7 per cent if the nitriding time were reduced from 72 to 10 hr.

On nitrided hollow specimens (bore 0.232 in.) with an 0.02-in. oil hole, the first cracks appeared at the outside surface. Since the specimens nitrided for 10 hr had a slightly harder surface, they had a little higher fatigue limit than those treated for 72 hr. It is therefore recommended to nitride crankshaft and airscrew shafts only 10 hr. The depth of the case is then 0.004 in. and this appears adequate for wear resistance considering its greater hardness. Since distortion and growth would be reduced, grinding operations after nitriding 10 hr might be replaced by honing or lapping, thus also eliminating grinding cracks.

The tests confirm the known fact that the effective stress concentration is reduced by nitriding (from 1.90 to 1.22 for reversed torsion, and from 2.27 to 1.43 for reversed bending, as calculated from the author's data).

Tests were also made on three types of specimens 0.3-in. diam: solid, hollow (0.116-in. bore), and hollow with 0.02-in. oil hole. These were machined from a $3^1/_2$-in-diam Cr-Mo-V steel bar or from a 1-in-diam Ni-Cr-Mo steel bar. The former steel had a 50 per cent higher static tensile strength than the latter, and specimens from it averaged 31 per cent higher in fatigue strength. For both steels the central bore reduced the fatigue strength by 1 per cent and the oil hole by about 50 per cent.

The interaction curves (graphs of limiting normal stresses σ due to reversed bending against limiting shear stresses τ due to reversed torsion) are all nearly elliptical, so that limiting combinations of σ and τ are given by the equation (not given in the paper): $(\sigma/\sigma_0)^2 + (\tau/\tau_0)^2 = 1$, where σ_0 and τ_0 are the fatigue limits for pure reversed bending and reversed torsion respectively.

Ferd. Budinský, Czechoslovakia

743. A. W. Hothersall, "Stress in electrodeposited metals," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 107–118.

Certain metals, particularly those of the iron group, are normally electrodeposited in a condition of tensile stress, while others—notably zinc—are normally electrodeposited in a state of compressive stress. In this paper, the author discusses the practical importance of knowledge about these stresses, describes the most important methods of measurement, summarizes published information, and reports on his own tests.

Stresses in electrodeposited metals are of practical importance because of their effect on the fatigue strength of the base metal, and particularly because of their effect on the success of the electroplating operation. The stress is usually measured by the bending of a thin-strip cathode which is plated on one side only. The bending can be measured by a variety of mechanical and optical methods, some of which allow the stress to be measured during deposition, and some of which give only residual stress. Conversion of bending of the strip to stress in the deposit is made by the formula: stress $= Ed^2D/(3l^2t)$ where E is Young's modulus, d is thickness of strip, D deflection of one end, l working length, t thickness of deposit, chromium, cobalt, copper, iron, nickel, and silver are normally deposited in a state of tension. This stress may reach 40,000 to 80,000 psi in chromium, cobalt, or nickel. Cadmium, lead, and zinc deposits are generally in compression which, for zinc, continues to increase after deposition is finished.

The author describes various theories which have been offered as explanations of the stress in electrodeposited metals. He states, however, that no comprehensive explanation of the phenomenon can be attempted until more data have been obtained, particularly on the correlation of crystal structure and stress and on changes in stress occurring after deposition.

B. F. Langer, USA

Design Factors, Meaning of Material Tests

(See also Revs. 755, 800)

744. Tadasi Isibasi, "On the fatigue limits of notched specimens" (in English), *Memo. Fac. Engng. Kyushu Univ.*, 1948, vol. 11, no. 1, pp. 1–31.

In this paper it is pointed out that two different kinds of fatigue fractures may occur in notched specimens under repeated loading. In the case of sharp-notched specimens a yielded zone will appear at a stress equal to the fatigue limit, and the notch factor β (the ratio of the fatigue limit of a plain specimen to that of a notched one) will be small compared with the form factor α (the theoretical stress-concentration factor). Considering a line in the direction of the maximum stress gradient, from a point at the root of the notch to a second point at which the normal stress is equal to the yield point and which is at a distance ϵ_0 from the first point, the normal stress along this line will then be considerably greater than the yield point of the material.

In case of an unsharp-notched specimen, the corresponding stress along a line from the root of the notch will only slightly exceed the yield point; however, up to a point at a greater distance ϵ_0' it will be larger than the fatigue limit of a plain specimen. In this case no yielding will appear before fracture and the notch factor will only be slightly smaller than the form factor. From this point of view the author discusses the magnitudes of ϵ_0 and ϵ_0', and states that they both are linear functions of the notch radius for similar notched specimens. It is also shown that the reciprocals of the fatigue limits and the curvatures of the root of the notch are connected by parabolic relations.

Whether a notch may be regarded as sharp or unsharp will depend on the stress gradient at the root of the notch and on the difference between the lengths ϵ_0 and ϵ_0'. The author assumes that a connection may be found between the magnitudes of ϵ_0 and ϵ_0', which are of the order 0.1 to 0.01 mm, and the grain size of the material. The results of this theoretical discussion are compared with the results of fatigue tests performed by the author as well as with results of previous tests made by American investigators, and are found to be in good agreement.

C. J. Bernhardt, Norway

Material Test Techniques

(See also Revs. 728, 744, 755, 799)

745. Sir Geoffrey Taylor and A. C. Whiffen, "The use of flat-ended projectiles for determining dynamic yield stress, I. Theoretical considerations, II. Tests on various metallic materials," *Proc. roy. Soc. Lond. Ser. A*, Sept. 2, 1948, vol. 194, pp. 289–299, 300–322.

In part I, G. I. Taylor derives a solution for the deformed shape of a flat-ended projectile striking a hard flat plate. From an analysis of the deformed shape of the projectile an approximate solution for the dynamic yield stress is obtained. In order to obtain a solution the author makes several limiting assumptions, such as that radial inertia is negligible. He defines strain as $1 - A_0/A$. The calculated values are for a cylinder the diameter of which is 0.3 of the height.

Since the assumption made in this solution, that the deceleration of the rear portion of the projectile is linear, is inexact, the

value of the yield stress so determined is always less than the true value. A correction for the yield stress is developed to improve this value. The ratio of the corrected dynamic yield stress to the static yield stress of paraffin is found to be 1.8.

In part II, A. C. Whiffin presents extensive experimental data from tests on flat-ended metal projectiles. These data are then used to determine the dynamic yield stress of the various materials used, by means of the method proposed in part I.

Frank J. Mehringer, USA

746. **Georges Welter, "Micro- and macro-deformations of metals and alloys under longitudinal impact loads,"** *Metallurgia*, 1948: Sept., vol. 38, pp. 287–292; Oct., vol. 38, pp. 328–330; Nov., vol. 39, pp. 13–17.

Longitudinal impact tests on aluminum, two aluminum alloys, a magnesium alloy, mild and medium steel are described. Most of the tests were tensile, a few compressive. The specimens were short, of gage length $2^1/_2$ to $3^1/_2$ in., and of diameter 0.25 to 0.375 in. Impact velocities were small, corresponding to falls up to 2 or 3 ft. The first two articles described tests with a modified Olsen pendulum machine. The other tests were made with a special machine consisting essentially of a weight falling between vertical guides to strike the specimen. The measurements made were: (1) the permanent strain after each impact, (2) the height of rebound of the Olsen pendulum.

The results of the tests made with the pendulum machine were unsatisfactory in that apparently only a small part of the energy of the pendulum acted in deforming the specimen. Thus, the measured dynamic elastic limit of 17S-T Dural is given as 30 to 35 ft-lbs per cu in., this being the energy of the pendulum required to produce a small permanent elongation which could be produced statically with approximately $^1/_{12}$ as much energy. In the tests made with the special machine this discrepancy was greatly reduced, and a ratio between dynamic and static elastic limit energies only slightly above unity was obtained.

In the reviewer's opinion a serious error has been made in presenting the results. Each specimen was subjected to a number of successive impacts whose effects were cumulative. That is, the permanent strain produced by a particular impact is in addition to the strain produced by all the previous impacts. The increment of strain is dependent on the amount of energy communicated to the specimen and on the hardness (yield strength) of the specimen in that particular state. The author seems not to have considered this and to have plotted the total strain after each impact as though it were a function of the intensity of that impact alone.

The third article deals mainly with the Bauschinger effect (reduction of elastic limit for tension by previous compression, and vice versa). This appears to be very strong with dynamic loading. This conclusion is probably not vitiated by the error discussed above.

Merit P. White, USA

747. **J. McKeown and L. H. Back, "A rotating-load, elevated temperature fatigue-testing machine,"** *Metallurgia*, Sept. 1948, vol. 38, pp. 247–254.

In developing a machine for high-temperature fatigue testing it was decided that the machine should operate on a principle similar to the Wöhler machines, so that fatigue data at lower temperatures would be directly comparable. Various attempts to measure accurately the temperatures of specimens in the normal Wöhler test in which a rotating cantilever specimen is subjected to a constant bending moment were unsuccessful. The machine was therefore designed to have the load rotate and not the specimen.

The new machine is described in detail by means of sketches. One end of the cantilever specimen is held stationary, and a constant rotating bending moment is applied by means of a rotating out-of-balance mass at the other end. A tubular furnace surrounds the specimen, the temperature of the furnace being controlled from 20 to 700 C by means of a Sunvic energy regulator and a tapped transformer. The temperature of the specimen is measured by means of a thermocouple in direct metallic contact with the neck of the specimen.

A formula is developed for the frequency of the cantilever specimen with its end load, in order to permit selecting a specimen which is stiff enough to insure that the critical speed is greater than the testing speed. A discussion of the proper calibration of the specimen, permitting a correct selection of load to produce the required stress, is included in the article. The dynamic limit of proportionality has been shown to be much higher than the static limit in some materials at elevated temperatures.

E. A. Brittenham, USA

748. **M. Marcel Prot, "Research on testing of cements. Study of a new type of test bars adaptable to different tests (Recherches sur les essais de ciments. Étude d'un nouveau type d'éprouvette susceptible de convenir a divers essais),"** *Bâtim. Trav. publics*, Jan. 1947: no. 35, pp. 1–35; no. 36, pp. 1–27.

Results are given of experimental studies directed toward eventual revision of (French) standards for rating cements. Tests were made on cast bars of mortars (cement sieved through 0.08-mm mesh, fine sand 0.3 to 0.5 mm, coarse sand 2 to 3 mm). It is suggested that a good test bar should have a simple shape so that large numbers can be formed under well-defined conditions, and should be suitable for a variety of mechanical tests. It is claimed that a parallelepiped (3.162 cm on a side and 9 to 10 cm long) fulfills these qualifications. The following tests are discussed: measurements of density, of shrinkage, of modulus of elasticity, and of Poisson's ratio; compression tests, tension tests, bending tests, shear tests, torsion tests, bending-fatigue tests, and impact tests. (Results of tension tests are stated to be "not yet" satisfactory due to difficulties of gripping the constant section parallelepipeds).

The critical reader may raise several objections to the author's approach: the small test bar is not suitable for testing cements in concretes containing large aggregates; the single shape is not equally suitable for every type of test; statistical evaluation of test results may have different interpretations. These objections will not be wholly answered by the author's emphasis upon the simplicity of the test bar.

Horace J. Grover, USA

Mechanical Properties of Specific Materials

(See also Revs. 695, 737, 742, 743, 745, 746, 748, 808)

749. **T'ing-Sui Kê, "Anelastic properties of iron,"** *Metals Technol.*, June 1948, vol. 15, T. P. no. 2370, 27 pp.

A typical anelastic property, the damping or internal friction, was studied in the stress range for which the phenomenon is independent of the stress level. Wires of high-purity iron were studied in a torsional decay apparatus mostly at a frequency of 1 cps for shearing strains less than 4×10^{-6}. Ferromagnetic hysteresis was apparently negligible at this low stress level. The wire was held in a furnace in an atmosphere of argon or nitrogen. The specimen was annealed at successively higher temperatures from 200 to 600 C, and for each annealing, the internal friction was measured at temperatures ranging from room temperature up to the particular

annealing temperature. Internal friction peaks were found around temperatures of 20, 225 and 490 C.

Experiments designed to analyze the relaxation phenomena associated with these peaks consisted in measurements of the internal friction as a function of temperature at two different frequencies, as well as tests in which the wire was purified from carbon and nitrogen. From the temperature difference between the two frequency peaks the heat of activation for the relaxation process was determined. The 20 C peak was found to be associated with a stress-induced preferential distribution of nitrogen atoms among the various interstitial positions in the solid solution of iron. The heat of activation for this relaxation was 20,000 cal per mole. The 225-deg peak was found to be due to the stress-induced diffusion of nitrogen atoms within some stress regions created in the specimen after subjection to cold work. The heat of activation for this diffusion was 32,000 cal per mole and the diffusion distance the order of a few atomic diameters. The 490-deg peak was caused by grain-boundary relaxation in the alpha-iron with a heat of activation of 85,000 cal per mole in agreement with the activation energy for self-diffusion in alpha-iron.

J. M. Robertson, USA

750. C. L. Altenburger, "Low-alloy high-tensile steels for automotive structures," *Soc. auto. Engrs. quart. Trans.*, Jan. 1949, vol. 3, pp. 145–155.

This is a discussion of the economic advantages of low-alloy high-tensile steels for automotive structures. Life and obsolescence factors, type of service, relative costs and fabrication problems are discussed. The corrosion resistance of high-tensile steels is considered important in prolonging the life of many automotive parts. The author also notes that the judicious use of the alloy steels enables more products to be made with available steel tonnage, which would greatly help our national economic problem.

Joseph Marin, USA

751. Ming-Kao Yen, "A study of textures and earing behavior of cold-rolled (87-89 pct) and annealed copper strips," *J. Metals*, Jan. 1949, vol. 1, pp. 59–66.

This paper considers the effect of phosphorus on the texture of five types of copper. Data for grain size, hardness, ear profiles from cupping tests, pole figures and glancing photograms are given. The principal contribution of the paper is the study of the effect of phosphorus on the cold-rolled and recrystallization textures, and the verification of the relation of texture to earing behavior.

Henry A. Lepper, Jr., USA

752. Hugh L. Logan, Harold Hessing, and Harold E. Francis, "Effect of artificial aging on tensile properties and resistance to corrosion of 24S-T aluminium alloy," *J. Res. nat. Bur. Stands.*, May 1947, vol. 38, pp. 465–489.

Commercially heat-treated 24S-T aluminum-alloy sheet was artificially aged at different elevated temperatures, and for various lengths of time. The effects of these treatments on (1) tensile properties of the sheet, and (2) corrosion resistance of the material were noted. The subject matter is treated in sufficient detail to give a fairly complete picture of test methods and procedure. Photographs are included, mostly to illustrate the corrosion racks employed. Results are given in detail as well as in summary. Tables, curves, and graphs are all used to advantage.

Care was exercised to account for the influence of all possible variables. Aluminum sheet used was obtained from two different commercial sources, each lot being chemically analyzed. Specimens and test pieces obtained from the sheet were cut with the direction of the "grain" noted. Corrosion tests included not only exposure and immersion alone, but also stress-corrosion tests in which the specimens were subjected to load while in corrosive mediums. Effect of exposure was obtained not only by noting changes in tensile properties, but also by visual and metallographic examination.

Conclusions are drawn with care and are based on a wealth of test information. Effect of artificial aging on yield strength is related to absolute temperature by plotting on semilogarithmic graph paper.

A. N. Zamboky, USA

753. Harold L. Walker and William J. Craig, "Effect of grain size on tensile strength, elongation, and endurance limit of deep drawing brass," *Metals Technol.*, Sept. 1948, vol. 15, T. P. no. 2478, 10 pp.

The paper discusses deep-drawing brass with a composition of 68 per cent Cu, 0.05 Pb and 32 Zn, whose grain size became 0.004 to 0.200-mm diam after cold rolling with a reduction of 71.5 per cent, and a subsequent annealing for $2^1/_2$ hr between 377 and 710 C. The study indicates that the mechanical properties of such a material may improve if the grain size is made smaller than is usual in industrial practice. When the grain size is reduced from 0.008 to 0.004 mm, the tensile strength rises from 5530 to 6130 psi and the endurance limit at 100 million cycles from 1800 to 2400 psi, while the elongation drops from 54 to 47 per cent. The elastic modulus of brass changes if the brass is subjected to reversals of stress, especially during the first few thousand cycles.

E. Siebel, Germany

754. G. O. Jones, "The mechanism of the reversible thermal aftereffects in glass at ordinary temperatures," *Proc. phys. Soc. Lond.*, Oct. 1948, vol. 61, pp. 320–326.

The author suggests an explanation for the reversible thermal aftereffects shown by glass, which are responsible for the zero depression in mercury-in-glass thermometers. Starting from a relation between these effects and the delayed elastic effects under ordinary mechanical stress, it is assumed that the thermal aftereffects are elastic strains resulting from stresses between regions of slightly different composition, these stresses being caused by the differing contractions of these regions during cooling.

The same reversible thermal aftereffects might be expected also in polycrystalline metals in which crystallites of differing composition and therefore expansivity occur together.

Franz Wever, Germany

755. J. Campredon, "Tests and researches on woods and their utilization (Essais et recherches sur les bois et leur utilisation)," *Bâtim. Trav. publics*, Oct. 1948, no. 45, pp. 1–16.

The author reviews the work of the National Timber Institute Laboratory at Paris for the year 1947-1948. The major part of the report deals with glued joints, glued members, and structures such as laminated curved beams and built-up girders. The author also discusses progress on creep tests on wood, as well as some tests on wood preservatives.

Frank J. Mehringer, USA

756. Gösta Lindeberg and Paul W. Lange, "Studies on the middle lamella of the flax fibre" (in English), *Proc. roy. Swed. Acad. engng. Sci.*, Jan. 1948, no. 198, pp. 5–41.

The great importance of the chemical and physical properties of the middle lamella in flax spinning, especially in working out a spinning technology suitable for green flax and in weaving this material, is discussed in an introduction written by Thor Svenzon.

In part I of the paper Gösta Lindeberg reports on investigations

of the strength and chemical composition of the middle lamella of flax. The author starts from the assumption that the textile strength of wet-flax fiber strands, for a test length greater than the length of the elementary fiber, depends on the chemical properties of the middle lamella, and any variation in this strength is mainly due to an alteration in the chemical constitution of the lamella. By determining the tensile strength of unretted flax strands (after treatment with different specific solvents), the author finds that the binding elements in the middle lamella are formed by pectin, by an extremely alkali-sensitive component containing uronic acids, and by lignin. It would seem that this procedure could be applied, along with microscopic examination, for studying the composition of the middle lamella in fibers other than flax.

In part II Paul Lange describes tests made by the ultraviolet microscopic method, which confirm the results set forth in part I.

D. DeMeulemeester, Belgium

Mechanics of Forming and Cutting

(See also Revs. 750, 751)

757. **A. J. W. Moore, "Deformation of metals in static and in sliding contact,"** *Proc. roy. Soc. Lond. Ser. A*, Dec. 7, 1948, vol. 195, pp. 231–244, 5 plates.

This paper deals with the surface deformation which occurs when a steel cylinder is pressed into a flat copper surface and when a hemispherical steel body slides on a copper surface.

An examination of the depression made by pressing a cylinder into a finely grooved copper surface shows that the grooves do not fully disappear even when the depression is so deep that considerable bulk deformation occurs. In the experiments on sliding, the speed of sliding was kept very small (0.01 cm per sec) to avoid any significant temperature rise between the surfaces. Sliding in the presence of a lubricant not only causes a furrow in the surface but also a marked leveling of the grooves, which disappear completely in dry sliding. The deformation becomes more pronounced when the sliding direction and the direction of the grooves intersect at greater angles.

By means of electrographic surface analyses it is shown that even in the presence of lubricant the steel surface tears out fragments from the copper surface, while minute steel particles are picked up by the copper surface. It is suggested that due to the high local pressure, actual welding occurs at the points of intimate contact, which causes shearing and rupture in the surfaces The main cause of friction is attributed to this mechanism.

J. H. Palm, Holland

758. **J. Rankine, W. H. Bailey, and F. P. Stanton, "Resistance strain gauges for the measurement of roll force, torque, and strip tension,"** *J. Iron Steel Inst.*, Dec. 1948, vol. 160, pp. 381–387.

The article explains in detail new methods developed to measure roll separating force, spindle torque, and strip tension in cold-rolling mills by the use of resistance strain gages. The methods have been used successfully on a small experimental cold-rolling mill at Sheffield University. The use of direct-current resistance strain-gage equipment greatly simplified former electronic arrangements. The tension meter consists of a combination of a torque meter and a device automatically dividing the value of the torque by the coil radius. The values of torque and tension are indicated on $2^1/_2$-in. pointer meters. The readings of these and similar meters used for other variables are recorded simultaneously by 35-mm motion-picture camera equipment.

E. A. Brittenham, Jr. USA

Hydraulics; Cavitation; Transport

(See also Revs. 763, 789)

759. **Norman Epstein and John B. Phillips, "Nonisothermal pressure drop for a gas,"** *Canad. J. Res. Sec. F*, Dec. 1948, vol. 26, pp. 503–512.

Two formulas for the pressure drop of turbulent gas flow in pipes are derived and compared with experiment when the pressure drop is small compared to the average pressure and the Reynolds number is small (6000 to 15,000), but the temperature change of the gas is large due to heating by the pipe wall. Both formulas give good agreement with experiment for air flow in a $^1/_4$-in. steam-jacketed pipe. The simpler one, first developed by McAdams for oils, is recommended.

K. W. Miller, USA

760. **R. C. Martinelli and D. B. Nelson, "Prediction of pressure drop during forced-circulation boiling of water,"** *Trans. Amer. Soc. mech. Engrs.*, Aug. 1948, vol. 70, pp. 695–702.

This paper presents a tentative practical method intended to permit prediction of the pressure drop for two-phase (boiling) flow in a pipe system from the presumably known pressure drop for single-phase flow in the same system. The frictional pressure drops are related empirically. The range of possible pressure drops due to change in momentum flow during passage is estimated by using conservation of momentum and the two extremes of possible exit conditions: vapor and liquids either completely mixed or completely separated. The degree of agreement with tests "indicates that the proposed method has promise."

Apparently little physical research has been done on this complex problem up to the present.

Stanley Corrsin, USA

761. **Marcel Ricaud, "On the oscillations produced by a stream in a channel under the influence of an obstacle (Sur les oscillations provoqués par une veine dans un canal sous l'influence d'un obstacle),"** *C. R. Acad. Sci. Paris*, Jan. 17, 1949, vol. 228, pp. 226–228.

The author found by experiment that if a vertical plate AB through the axis of the channel is placed downstream of a vertical slit in a gate of a rectangular channel, the free surface will oscillate, provided the upstream edge A of the plate is sufficiently close to the slit. These oscillations result from the superposition of two ripple trains L and T propagating along and across the main flow. Their measured velocity agrees with the Airy formula for gravity waves. The period of oscillation of L is independent of the mass flow, varies linearly with the length AB, and tends, with AB tending toward zero, to the period of the transverse oscillation T, which is independent of the length AB.

Giulio di Marchi, Italy

762. **E. Meyer-Peter and R. Müller, "A formula for the calculation of bed-load transport (Eine Formel zur Berechnung des Geschiebetriebs),"** *Schweiz. Bauztg.*, Jan. 15, 1949, vol. 67, pp. 29–32.

In this paper, which summarizes the one presented by the authors at the International Association for Hydraulic Structures Research at Stockholm in 1948, a new formula is presented for the calculation of bed-load transport, not including the suspension load. The formula is based on theoretical considerations concerning the bottom shear stress (using the Strickler-Manning formula) and numerous experiments carried out in a rectilinear canal at the Laboratory for Hydraulic Research and Soil Mechanics of the Swiss Federal Institute of Technology in Zurich. The problem of dividing the energy transformation into two parts,

one caused by side-wall friction and one caused by bottom conditions, is solved by a method published by A. Einstein [*Schweiz. Bauztg.*, Feb. 24, 1934, pp. 89–91].

In their experiments the authors used bottom material with a natural specific gravity (in tons per cu meter) $\gamma_s = 2.68$, baryta with $\gamma_s = 4.2$, lignite breeze with $\gamma_s = 1.25$, and with both uniform and nonuniform size of grains (characterized by a certain formal mean diameter d_m). The slope was varied from 0.0004 to 0.020, the size of particles (d and d_m) from 0.0004 to 0.030 meters, water depths from 0.01 to 1.20 meters, and discharge from 0.002 to 2.0 cu meters per sec per meter width. Natural examples were chosen as prototypes for the experiments, using the Froude law of similarity. The resulting formula, with really nondimensional constants and valid for all the experiments with satisfactory accuracy, gives the relation between the bed-load transport per sec per unit width of bed (by weight in water), the properties of the bed material and the flow conditions.

A special result of the formula is that the limiting shear stress at the bottom (that is, the bottom shear stress at which the bed-load transport begins) is proportional to the specific gravity γ_s (under water) of the bed material and the afore-mentioned mean diameter d_m; however, the authors call attention to an uncertainty as to the determination of the constant of proportionality.

With this interpretation, however, the formula shows that the bed-load transport (by weight in water) depends, besides on the mass density of the fluid, only on the difference between the effective and the limiting shearing stress. This simple result has not yet been confirmed by experiments with fluids of a specific gravity different from one ton per cu meter.

The authors intend to extend the range of experiments, after an extension of the experimental canal, in order to examine bed-load transport at very small slopes (corresponding to small Froude numbers) and small values of the relative magnitude of bed material d_m/R, R being the hydraulic radius. The results of such experiments will be awaited with the greatest interest.

Hans Thygesen Kristensen, Denmark

Incompressible Flow: Laminar; Viscous

(See also Revs. 698, 759, 760, 762, 765, 780, 781, 790, 805, 808, 811)

763. M. I. Gurevich, "Some remarks on stationary schemes for cavitation flow about a flat plate," *David Taylor Model Basin Rep.*, no. T-224, Nov. 1948, 17 pp.

The author treats the problem of the drag of a flat plate normal to a flow. He reviews briefly the results obtained by Betz, Riabouchinsky, Weinig and Efros for cavitation numbers not equal to zero. The author offers a solution of the problem which is based on the assumption that the velocity along the boundary streamlines decreases from V_α at the plate to V_∞ far behind the plate. However, since the rate of decrease of velocity is not known, he assumes that the boundary in the ζ-plane [see Lamb's *Hydrodynamics*, 6th ed., p. 98] is a semiellipse instead of a semicircle and solves the problem on that assumption. The author concludes that all the theories give closely similar values for the drag.

The translator, in an appendix to the paper, makes some remarks on the computation and adds two other references.

Dino A. Morelli, USA

Compressible Flow, Gas Dynamics

(See also Revs. 778, 779, 786, 787, 788)

764. Harold W. Siebert, "High-speed aerodynamics," Prentice-Hall Inc., New York, 1948. Cloth, 8.5 × 5.5, 289 pp., 48 figs.

This book is specifically written for engineering students and practicing engineers. Prerequisites for its understanding are differential and integral calculus and a knowledge of elementary aerodynamics. Knowledge of thermodynamics and flow of incompressible fluids is desirable but not essential. Within this well-defined scope a large portion of compressible and supersonic flow theory is presented, as well as its application to many practical problems. The contents of the book are arranged in 29 chapters followed by a number of useful tables and charts. Each chapter contains a brief introductory paragraph defining its scope and purpose.

Chapters 1 to 4 present fundamental relations, thermodynamical relations, energy, Bernoulli and Euler equations, entropy and isentropic flow. Chapters 5 to 9 define and discuss the speed of sound, the Mach number, dynamic and impact pressures, pressure coefficients, and critical conditions. Chapters 10 to 13 contain the standard atmosphere, altimeter, air-speed indicator, Mach meter, and their position errors and definitions of true, indicated, calibrated and equivalent air speeds. Chapters 14, 15, and 16 cover aerodynamic heating, reversible adiabatic flow, and one-dimensional flow, respectively. Chapter 17 gives the derivation of the partial-derivative equations for compressible flow, and chapter 18 presents the disturbance potential including the Prandtl-Glauert formula, followed by Ackeret's supersonic theory in chapter 19. Chapters 20 and 21 give the shock-wave equations, chapter 22 the supersonic flow around a wedge, and chapter 23 the Prandtl-Meyer flow around a corner. Busemann's parabolic formula is given in chapter 24 and the flow around a cone in chapter 25. Chapters 26 to 29 present a discussion of practical problems, such as high-subsonic Mach number effects on airplanes, sweepback and low-aspect-ratio wings, and experimental determination of high-speed data.

Each chapter includes a set of problems.

H. P. Liepman, USA

765. Stefan Bergman and Bernard Epstein, "Determination of a compressible fluid flow past an oval-shaped obstacle," *J. Math. Phys.*, Jan. 1948, vol. 26, pp. 195–222.

This paper shows how the hodograph method developed by Bergman in previous papers can be applied to the calculation of compressible flows past closed bodies. Certain universal functions are tabulated, and one example is worked out explicitly. This is the flow past a nearly elliptic cylinder.

General considerations are presented at the beginning and the end of the paper. It is pointed out that even the incompressible flow past a given body cannot be calculated easily. Further developments of the hodograph method, using other theories developed by Bergman, are indicated.

C. C. Lin, USA

766. Robert T. Jones, "Thin oblique airfoils at supersonic speed," *Nat. adv. Comm. Aero. Rep.*, no. 851, 1946 (issued in 1949), pp. 1–9.

This report, previously issued by the same source as *Technical Note*, no. 1107, deals with the application of the linearized theory of supersonic compressible flow to thin airfoils of various sections and with variations in taper and sweepback. Solutions are developed in terms of oblique-line sources and the pressure and wave drag coefficients are calculated. Single-wedge, double-wedge and biconvex shapes are among the cross sections considered. All calculations are for the symmetric sections at zero lift.

M. J. Thompson, USA

767. S. M. Harmon and M. D. Swanson, **"Calculations of the supersonic wave drag of nonlifting wings with arbitrary sweepback and aspect ratio. Wings swept behind the Mach lines,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1319, May 1947, pp. 1–40.

On the basis of R. T. Jones's method of line sources [see same source, no. 1107] the wave drag of nonlifting symmetric airfoils (biconvex parabolic arc profile) is computed. The plan forms considered have no taper, are swept back behind the Mach lines originating at the apex, and are cut off parallel to the direction of flight. The results are represented by plotting the drag parameter $C_D \tan \Lambda/[100(t/c)^2]$ versus $A \tan \Lambda$ for $0 \leqq (M^2 - 1)^{1/2} \cot \Lambda \leqq 1$, where Λ is the sweep angle, A the aspect ratio, t/c the per cent slenderness and M the Mach number. The underlying formulas are fully presented.

Mathematically, this paper presents a certain type of solutions of the linearized three-dimensional compressible potential-flow problem. However, each line-source solution fulfills the appropriate boundary condition only in the half plane where it is located, so that the over-all boundary conditions are only approximately satisfied.

G. Kuerti, USA

768. Sidney M. Harmon, **"Theoretical supersonic wave drag of untapered sweptback and rectangular wings at zero lift,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1449, Oct. 1947, pp. 1–43.

The analysis of the wave drag of nonlifting airfoils discussed in the preceding review is extended to wings with leading edges in front of the Mach lines originating at the apex of the wing. Profiles and plan forms used are the same as before and the computations are based on the same theory. It may be noted that the rectangular plan form belongs to the class of airfoil studied here. The results are presented in terms of the parameters mentioned in the preceding review, and typical curves of the section lift coefficient as a function of the span station, with and without tip effect, are also supplied. The underlying formulas are fully presented.

G. Kuerti, USA

769. Louis Viaud, **"Contribution to the study of supersonic two-dimensional flow (Contribution a l'étude des écoulements supersoniques a deux dimensions),"** *Off. nat. Étud. Rech. aéro. Rep.*, no. 13, 1948, 14 pp., 5 charts.

The pressure ratio across oblique shocks or expansion waves is plotted in two graphs as a function of upstream Mach number and of flow deflection. The changes of flow and state parameters resulting from the intersection of such waves in steady two-dimensional flow are graphically determined by matching pressure and flow direction downstream of the intersection.

Joseph V. Foa, USA

770. D. R. Davies, **"Shock waves in air at very high pressures,"** *Proc. phys. Soc. Lond.*, Aug. 1948, vol. 61, pp. 105–118.

From the shock-wave equations, expressing the change of internal energy and flow velocity across the shock in terms of initial and final pressures and specific volumes, one may calculate all the shock quantities of interest, provided the internal energy and specific volume as functions of pressure and temperature are known.

To permit such calculations for strong shock waves in air, which give rise to pressures up to 1000 atm and temperatures up to 16,000 K behind the shock, the author has, first of all, calculated the internal energy and specific volume for air at various states. Dissociation of oxygen and nitrogen molecules into atoms was considered. In the first instance, the presence of argon and the formation of NO were neglected; later, the presence of these constituents was also considered.

Typical results are: at 1000 atm behind the shock, the velocity of shock advance in standard air at rest is 9310 meters per sec, the velocity of the air behind the shock is 8450 meters per sec, the temperature behind the shock is 14,000 K and the specific volume 71.8 cm per g. Following the shock, the composition of the gas in percentages is: 0.27 NO, 23.01 O, 0.05 O_2, 58.96 N, 16.41 N_2 and 1.30 A. At lower pressures the NO concentration is higher.

Stewart Way, USA

771. M. P. Emery, **"Numerical values in the equation of supersonic nozzles (Valeurs numériques dans les équations des tuyères supersoniques),"** *Mémor. Artill. fr.*, 1948, vol. 22, no. 2, pp. 259–275.

The author gives an accurate method for computing the ratio of specific heats (γ) of combustion gases flowing through nozzles. The method is based on the consideration of enthalpy and entropy. A simple example is given to show the accuracy of this method. For the temperature at the throat the deviation is only about one per cent, and the ultimate velocity deviates less than three per cent from the results of calculations on the basis of the mean value of γ.

A. D. Kafadar, USA

772. R. R. Jamison and D. L. Mordell, **"The compressible flow of fluids in ducts,"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2031, Mar. 1945 (published in 1948), pp. 1–73.

A number of graphs are presented showing the relations between the principal variables encountered in the analysis of compressible axial flow. The information is plotted in terms of nondimensional parameters, covers subsonic, transonic and supersonic ranges and takes friction into account. Examples of the use of the curves are included in the text.

John E. Goldberg, USA

773. C. A. Truesdell, **"On the differential equations of slip flow,"** *Proc. nat. Acad. Sci. Wash.*, July 1948, vol. 34, pp. 342–347.

What the author seems to aim at in this paper is a very comprehensive theory of the motion of a viscous compressible fluid, which may be a mixture of several substances and anisotropic. The argument is condensed and on that account difficult to follow. Contrary to the implication of the title, differential equations of motion are not written down, and the discussion centers on a formula expressing stress as a power series in the viscosity μ, the coefficients up to that of μ^3 being given explicitly for an isotropic fluid. These coefficients are functions of a considerable number of variables which include temperature, mean pressure p_m, gradient of pressure p (p is defined thermodynamically), gradient of body force, the rate of deformation tensor, the vorticity tensor, and higher derivatives of these quantities. The author draws attention to one rather startling and physically improbable consequence of his theory, namely, that a mass of fluid rotating as a rigid body experiences a stress which depends on the viscosity. A fuller account of the theory is to appear elsewhere.

Courtesy of Mathematical Reviews J. L. Synge, Ireland

Turbulence, Boundary Layer, etc.

(See also Rev. 810)

774. W. Heisenberg, **"On the theory of statistical and isotropic turbulence,"** *Proc. roy. Soc. Lond. Ser. A*, Dec. 22, 1948, vol. 195, pp. 402–406.

If it is assumed that the action of the smaller eddies in turbulent flow can be represented by an additional viscosity, it is possible to

write down an expression for this viscosity in terms of the energy distribution function. The consequences of this assumption are worked out, and solutions for the variation of energy with wave number (proportional to frequency) and time are derived. The question of whether the actual turbulent motion will correspond to one of these solutions is discussed, and it is shown that the largest eddies cannot partake in the statistical equilibrium postulated.

According to the author the old conception of turbulence was that it was caused by viscosity which prevented the realization of the classical ideal fluid flows, in which the fluid glides along the walls. The newer idea is that a fluid without viscosity is a system with an infinite number of degrees of freedom. As soon as one puts energy into an inviscid fluid, this energy will be distributed among all the degrees of freedom. It is the viscosity which reduces the number of degrees of freedom since it damps very quickly all motions in the very small eddies. Turbulence is the statistical problem of determining the distribution of energy among a large number of degrees of freedom. H. B. Squire, England

775. J. M. Burgers, "A mathematical model illustrating the theory of turbulence," *Advances in Applied Mechanics*, Academic Press, Inc., New York, 1948, vol. 1, pp. 171–199.

The author considers a mathematical model of a hydrodynamic system to illustrate the theory of turbulence. The paper is a survey and an extension of the work presented by him in a well-known series of earlier publications. Although the system adopted is very simple, it is capable of illustrating many of the main features of turbulent motion, such as the thin dissipation layers arising from small kinematic viscosity, the transfer of energy through the spectrum to high frequencies, and the appearance of a practical limit to this spectrum (responsible for the finite value of the total dissipation). A process of energy balance very similar to that in actual turbulent motion is thereby represented. In particular, the recent results on the correlation function $R(r)$ $[1 - R(r) \sim r^{2/3}]$ and on the spectrum $E(k)$ $[E(k) \sim k^{-5/3}]$ at large Reynolds number are also reproduced in the model system. The main part of the paper deals with a model system having one component of turbulent motion; an extended model having two components is also discussed.

Courtesy of Mathematical Reviews C. C. Lin, USA

776. A. Fage, "The smallest size of a spanwise surface corrugation which affects boundary-layer transition on an aerofoil," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2120, Jan. 1943 (issued in 1948), pp. 1–19.

Experiments are described from which the author has obtained the following empirical relations for the minimum height of a spanwise surface corrugation that will affect the position of transition in a laminar boundary layer:

$$h/L = 13.5 \times 10^6 r^{-3/2} (XB)^{1/2}/L, \text{ for } (BX)^{1/2} < .09L;$$

$$h/L = 9 \times 10^6 r^{-3/2} (B/L)^{1/2}, \text{ for } (BX)^{1/2} > .09L,$$

where h is the minimum height, L is the length of the laminar boundary layer, $r = w_{1c}L/\nu$, w_{1c} is the velocity just outside the layer at the corrugation position, B is the width of the corrugation, and X is the distance of the corrugation behind the leading edge of the airfoil. For these tests r was varied from 10^6 to 3.5×10^6. The form of the corrugation did not substantially affect these results. The velocity gradients over the minimum corrugations were large compared with the gradient over a smooth laminar flow airfoil. While the range of validity of extrapolation is not known, fair agreement was obtained in flight test up to values of r of 5×10^6. J. M. Wild, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 700, 730, 764, 766, 767, 768)

777. G. E. Pringle, "The difference between the spinning of model and full-scale aircraft," *Rep. Memo. aero. Res. Counc. Lond.*, no. 1967, May 1943 (issued in 1948), pp. 1–19.

In this paper existing standards for the prediction of satisfactory spin-recovery characteristics of full-scale aircraft, as determined by spinning models, are examined critically. A number of full-scale tests are correlated with model tests on the basis of a single parameter subject to statistical variation on the scale of yawing moments. No entirely satisfactory procedure for full-scale prediction is found, particularly when the models appear to be sensitive to applied rolling couples, but the possibility of revising the standards is seen when more full-scale data are accumulated. J. M. Wild, USA

778. W. F. Hilton, "Empirical laws for the effect of compressibility on quarter-chord moment coefficient, and for the choice of an aerofoil with small compressibility effects on centre of pressure," *Rep. Memo. aero. Res. Counc. Lond.*, no. 2195, Mar. 1943 (issued in 1948), pp. 1–16.

This paper deals with the development of a simple empirical relation for calculating the effect of Mach number on the quarter-chord pitching-moment coefficient of an airfoil at subsonic speeds. The Prandtl-Glauert and von Kármán relations are discussed and are shown to be somewhat unsatisfactory at Mach numbers approaching the critical value. The empirical formula developed pertains to variations in both Mach number and airfoil thickness ratio, and is based on test data obtained prior to 1943. Applications of the formula to aerodynamic design problems are shown for several typical cases. M. J. Thompson, USA

779. William N. Turner, Paul J. Steffen, and Lawrence A Clousing, "Compressibility effects on the longitudinal stability and control of a pursuit-type airplane as measured in flight," *Nat. adv. Comm. Aero. Rep.* no. 854, 1946 (issued in 1949), pp. 1–15.

This report describes measurements of longitudinal stability and control of an aircraft in flight at Mach numbers up to 0.78. Experiments of this kind have been made on many aircraft in the last few years, and the results in this case are typical. There is large increase in stability, both stick-fixed and stick-free, at the highest Mach numbers, together with a powerful nose-down pitching moment. The experiments are noteworthy for their precision, unusual in such difficult flight tests, and for the careful examination of the influence of elevator distortion.

The brief explanations of the observed phenomena given in the text are somewhat inadequate in the light of the present-day knowledge. For example, the impression is erroneously given that the increase in stability at the higher Mach numbers will only persist until the tail, as well as the wing, is shock-stalled. R. Smelt, USA

780. John D. Bird, "Some theoretical low-speed span loading characteristics of swept wings in roll and sideslip," *Nat. adv. Comm. Aero. tech. Note*, no. 1839, Mar. 1949, pp. 1–36.

The Weissinger method for determining additional span loading for incompressible flow is used to find the damping in roll, the lateral center of pressure of the rolling load, and the span-loading coefficients caused by rolling, for wing plan forms of various aspect ratios, taper ratios, and sweep angles. In addition, the applicability of the method to the determination of certain other aerodynamic derivatives is investigated, and corrections for the first-order effects of compressibility are indicated.

The agreement obtained between experimentally and theoretically determined values for the aerodynamic coefficients indicates that the method of Weissinger is well suited to the calculation of the additional span loading caused by rolling, and to the calculation of those resulting aerodynamic derivatives for wings which do not involve considerations of tip suction.

Andrew Vazsonyi, USA

781. J. Greidanus, **"The loading of airplane structures by symmetrical gusts"** (in Dutch), *Nat. LuchtLab. Amsterdam Rap.*, no. 14, 1948, 77 pp.

This report describes a systematic theoretical investigation of gust loads on airplanes, carried out during the war. The acceleration factor of the center of gravity is expressed as

$$n = 1 + {}^1/_2\, \rho w_0\, U(F/G)k\Lambda$$

where ρ is air density, w_0 maximum gust velocity, U flight speed, F wing area, G airplane weight, k slope of wing-lift curve and Λ the alleviating factor. In the investigation allowance is made for aerodynamic lag and for the motion of the airplane in the vertical direction and around its lateral axis. It appears that the maximum value of the alleviating factor Λ_{max} mainly depends on three parameters: (a) the ratio of gust-gradient distance, that is the horizontal distance over which the gust velocity increases from zero to its maximum value w_0 at the wing half-chord; (b) the airplane parameter $C = {}^1/_2\, \rho\, glk\, F/G$, where l is the wing half-chord and g the acceleration of gravity; (c) the location of the airplane center of gravity behind the aerodynamic center of the wing.

The detailed structure of the gust-field transition zone appears to be unimportant. Furthermore it is shown that for gust-gradient distances smaller than about ten wing chords the alleviating factor is nearly independent of this gradient distance. The effect of a rearward displacement of the center of gravity is to increase the gust-load factor.

In addition to the analysis of the linear acceleration factors, calculations are given for the angular accelerations and tail loads. The results are more complex and are therefore less easily interpreted as design rules.

Next an analysis is made of the effect of wing flexibility on the internal wing loads, taking into account the fundamental bending mode. The assumption is made that the oscillating part of the wing motion is undamped. It is found that for wings with a high natural frequency an appreciable increase in internal loads arises only for very short gust-gradient distances. On the other hand, the increase of internal loads may be large for low-frequency wings, even for medium and large gust-gradient distances; this may occur in the flexible wings of modern large aircraft. It would seem that aerodynamic damping of the wing oscillations cannot be neglected in such cases.

Finally the theory is compared with experimental data published before the war. The agreement is satisfactory so far as experimental evidence is available.

W. T. Koiter, Holland

782. W. J. Duncan, **"The cause of the spontaneous opening and closing of parachutes (the phenomenon of "squidding"),"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2119, Dec. 1943 (issued in 1948), pp. 1–9.

The ratio of the mean axial velocity through the mouth of a porous canopy to the velocity of the canopy relative to the undisturbed air increases with the latter velocity. The effective angle of attack of the lip concurrently decreases, and may even become negative at a critical value of the relative air speed. The canopy will then collapse to what has been called the "squid shape."

Joseph V. Foa, USA

783. W. J. Duncan, G. W. H. Stevens, and G. J. Richards, **"Theory of the flat elastic parachute,"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2118, Mar. 1942 (issued in 1948), pp. 1–18.

A flat parachute is one whose unloaded canopy can be developed into a plane sheet. This report gives a mathematical treatment of the behavior under load of such canopies. If the hem and attachments are well designed, failure will occur at the crown where the tension is greatest. This tension is calculated assuming that the canopy near the crown is a surface of revolution up to a critical radius where the circumferential tension vanishes.

Joseph V. Foa, USA

784. Louis Blanjean, **"The action of wind on structures (L'action du vent sur les constructions),"** *Ossature métallique*, Feb. 1949, vol. 14, pp. 91–111.

An explanation and summary of new Belgian specifications for wind pressures on structures are given. Data are reported for pressure distributions, drag coefficients and lift coefficients for cylindrical tanks of different proportions and with different types of roofs, for spherical tanks, for isolated structural shapes, and for trusses. Most of these data were obtained by wind-tunnel tests on models of the structures.

Dana Young, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 781)

785. M. Z. Krzywoblocki, **"A note on natural frequencies,"** *Aircr. Engng.*, Feb. 1949, vol. 21, pp. 49–54.

Using generalized coordinates for a wing-fuselage system with viscous damping, expressions are derived for the natural flexural and torsional frequencies. With aerodynamical forces exciting the wing, the author states that a sharply peaked resonance curve is desired to give the pilot warning of approaching resonance, and therefore materials of low damping are suitable.

J. M. Robertson, USA

786. G. F. Carrier, **"The oscillating wedge in a supersonic stream,"** *J. aero. Sci.*, Mar. 1949, vol. 16, pp. 150–152.

This paper considers an interesting effect of the nose shock wave on the aerodynamic behavior of a fluttered supersonic wing. For preliminary investigation, a two-dimensional wedge with a finite chord is allowed to oscillate slightly about the leading edge in a supersonic stream. Accordingly, the nose shock wave will become wavy relative to the wedge. The acoustic waves that are reflected from such a wavy shock may cause some modification of the pressure distribution determined from the linearized flutter theory. For this first-order effect, some perturbation wave functions can be defined and evaluated by means of series expansions from the boundary condition at the wedge surface.

It is found that the presence of the shock cannot be disregarded in computing the pressure on the wedge. The weak shock solution is not appreciably altered by the omission of the shock boundary condition, but the solution associated with stronger shock undergoes an appreciable change. Of course, the investigation cannot hold for the cases of detached shock or of a very large amplitude of oscillation.

Chieh-Chien Chang, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 703, 705)

787. Saul Dushman, "Scientific foundations of vacuum technique," John Wiley & Sons, New York, 1949. Cloth, 9.2 × 6 in., 882 pp., 326 figs., $15.

Beginning with the early days of the incandescent filament lamp, through the development of the vacuum tubes, and finally with the recent requirements of atomic research, vacuum technique has gained tremendously in importance over the last thirty to forty years. The General Electric Research Laboratory has been one of the pioneers in this field and there was hardly a person better qualified than the author, who is assistant director of this laboratory, to write a book on the scientific foundations of vacuum technique. It is the result of over thirty years of experience, gained during actual participation in the development of the field and it comes as a timely publication which fills a definite gap in scientific literature.

With the emphasis on the scientific principles, 125 pages of the book are devoted to the kinetic theory and the flow of gases through tubes and orifices. An equal space is devoted to vacuum pumping equipment, which is divided into mechanical pumps, steam jet ejectors, mercury vacuum pumps, and vapor pumps using organic liquids. Manometers for low gas pressures and leak detectors are treated, taking into account various types such as mercury and other liquid manometers. Also treated are mechanical, viscosity, radiometer, heat-conductivity, and ionization gages. Sorption of gases and vapors by solids in general, by "active" charcoal, silicates, cellulose, and the general interaction between gases and metals are covered in three further chapters. Finally, chemical and electrical cleaning of gases, vapor pressures and rates of evaporation, and dissociation pressures of oxides, hydrides and nitrides are discussed. References to the current literature are given throughout the book and a complete index of subjects and names is added, which increases the value of the book for reference purposes.

While the book intentionally has not dealt specially with experimental procedures but has "attempted to present a survey of fundamental ideas in physics, chemistry, and (to a smaller extent) metallurgy, it will be found useful to both the scientist and engineer in dealing with problems in the production and measurement of high vacua."

Otmar E. Teichmann, USA

788. W. Perl and H. T. Epstein, "Some effects of compressibility on the flow through fans and turbines," *Nat. adv. Comm. Aero. Rep.*, no. 842, 1946 (issued in 1949), pp. 1–7.

This paper is an analysis of compressible flow through a two-dimensional cascade of airfoils. The basic equations of conservation of mass, momentum and energy are applied to find relations between up- and downstream angles, the inlet Mach number and the pressure ratio for both compressor and turbine cascades.

The results are shown in graphical form and compared with the corresponding results for incompressible flow. The data give a very clear picture of the effect of compressibility for both compressor and turbine cascades. The graph shows also two ranges of flow angles and inlet Mach numbers for which no ideal pressure ratio exists. For practical application it is important to remember that stalling and deviations from two-dimensional flow will limit the actual range of flow angles below that shown in the graph. The effect of change in axial-flow area is considered in the formulas and is of importance in many applications. For inlet Mach numbers less than 0.4 the relations for compressible and incompressible flow give very nearly the same results in the case of axial-flow compressors.

H. E. Sheets, USA

789. L. Escande, "Remark on the maximum pressure generated by hydraulic control systems with discharge valves (Remarque sur la surpression maxima engendrée par la régulation des groupes hydroelèctriques munis de déchargeurs)," *Houille blanche*, 1948, no. spec. A, pp. 585–599.

The paper discusses the increase of pressure in the conduits of hydroelectric groups equipped with dischargers for the release of a certain amount of water, when the flow through the hydroelectric units is more or less rapidly reduced. The effect of water hammer is considered as a wave phenomenon. A number of cases different in initial conditions and mode of operating the discharger are calculated, partially by means of a graphical method.

Wilhelm Spannhake, USA

Flow and Flight Test Techniques

(See also Revs. 777, 779)

790. S. Katzoff, Clifford S. Gardner, Leo Diesendruck, and Bertram J. Eisenstadt, "Linear theory of boundary effects in open wind tunnels with finite jet length," *Nat. adv. Comm. Aero. tech. Note*, no. 1826, Mar. 1949, pp. 1–97.

In the first part of this paper, the boundary conditions for an open wind tunnel (incompressible flow) are examined with special reference to the effects of the closed entrance and exit sections. Basic conditions are that the velocity must be continuous at the entrance lip and that the velocities in the upstream and downstream closed portions must be equal. For the two-dimensional open tunnel, interesting possibilities develop from the fact that the pressures on the two free surfaces need not be equal. Electrical analogies that might be used for finding the flow in open wind tunnels are outlined: one in which electric potential corresponds to velocity potential, and another in which electric potential corresponds to acceleration potential.

In the second part, solutions are derived for four types of two-dimensional open tunnels, including one in which the pressures on the two free surfaces are not equal. Numerical results are given for every case. In general, if the lifting element is more than half the tunnel height from the inlet, the boundary effect at the lifting element is the same as for an infinitely long open tunnel.

In the third part is given a general method for calculating the boundary effect in an open circular wind tunnel of finite jet length. Numerical results are given for a lifting element concentrated at a point on the axis.

H. P. Liepman, USA

Thermodynamics

(See also Revs. 700, 759, 770, 771, 787, 796, 797)

791. Matts Bäckström, "A peculiar thermodynamical analogy," *Trans. roy. Inst. Technol. Stockholm*, no. 7, 1947, pp. 1–12.

The analogy discussed in this paper deals with a comparison of the characteristics of a surface condenser (for instance, for condensing steam) and the temperature dependence of the specific heat of a solid. The specific heat of a monatomic solid can be expressed as a function of the ratio of temperatures corresponding to certain molecular energy states. The derivative of condensing temperature with respect to the mean temperature difference for a surface condenser is precisely the same function (except for a constant factor) of the ratio of cooling the water-temperature rise to the mean temperature difference. The author explores the causes of this analogy.

Stewart Way, USA

792. Tsung-Chi Tsu, "Theory of the inlet and exhaust processes of internal-combustion engines," *Nat. adv. Comm. Aero. tech. Note*, no. 1446, Jan. 1949, pp. 1–94.

A theory based on the first law of thermodynamics and the laws of fluid mechanics is developed for the calculation of the mass of

fluid pumped per stroke, and of indicator diagrams for the pumping process of internal-combustion engines, compressors, or vacuum pumps. The data needed are few and easily obtained. Thus, the volumetric efficiency and the indicator diagrams for the inlet and exhaust processes of an internal-combustion engine can be obtained even before the engine is actually built. Comparisons made between calculated and experimental results tend to verify the theory; for example, calculated values of volumetric efficiency are only about five per cent higher than the measured values.

The fluid-mechanics equations of motion when applied to intake and exhaust processes reduce to an equation involving the terms of the Bernoulli equation and a term which accounts for the inertia forces due to the unsteadiness of flow. It is shown by examples that this latter term is indeed small in this application.

It is found from calculations that, when other things are kept constant, volumetric efficiency varies with the ratio of inlet pressure to exhaust pressure regardless of the absolute magnitudes of either.

The theory also indicates that for the inlet process the effect of decreasing the speed is the same as that of increasing the size of the inlet valve relative to the piston or increasing the velocity of sound in the intake charge; and for the exhaust process the effect of decreasing the size of the exhaust valve relative to the piston or increasing the velocity of sound in the ideal residual gas.

Warren M. Rohsenow, USA

Heat Transfer; Diffusion

(See also Rev. 760)

793. P. Vernotte, "Application of the molecular mechanism to an approximate theory of the phenomena of heat flow (Application du mécanisme moléculaire à une théorie approchée des phénomènes thermocinétiques)," *C. R. Acad. Sci. Paris*, July 12, 1948, vol. 227, pp. 114–116.

The author considers the problem of heat conduction with a coefficient varying with time. C. C. Lin, USA

794. Fritz Möller, "Scattered radiation due to atmospheric fog and secondary diffusion (Streustrahlung des atmosphärischen Dunstes und sekundäre Diffusion)," *Met. Rdsch.*, Jan.-Feb. 1948, vol. 1, pp. 212–215.

By comparing the measured distribution of the scattered radiation in a hazy and dusty atmosphere with the theory of the scatter of light by small particles, it has been found that the majority of the small droplets in the atmosphere have radii of about 10^{-4} mm. This agrees with the size generally accepted for the particles forming the nuclei of condensation for the saturated vapor contained in the air. The bigger dust particles thus do not seem to have an influence on the distribution of the scattered radiation. To make sure that the measured values of this distribution are not affected by secondary diffusion, a calculation was carried out which showed that secondary diffusion has only a minor influence on the distribution of the scattered radiation, thus indicating that the above conclusions are basically correct.

E. Haenni, USA

Acoustics

795. P. Liénard and M. Kobrynski, "General principles of quieting planes (Les principes généraux de l'insonorisation des avions)," *Rech. aéro. Paris*, Nov.-Dec. 1948, no. 6, pp. 57–64.

The problem of reducing the noise level within airplanes is surveyed, with references to a few other articles and a forthcoming book. Noise should be combated by reducing it at the sources (mainly propellers, engines, and aerodynamic disturbances), by optimum location of the sources with respect to the cabin, by decreasing wall transmission, and by promoting absorption within the cabin. Each step is discussed briefly. A few measurements of noise levels in French civil planes are quoted and compared with available data on American military planes. (Some attention had been given to quieting in all of the examples.) In general, the noise is still too great for comfort and intelligible speech. The authors emphasize the practical design compromises which hinder quieting, and maintain that continued fundamental study is more important than an empirical approach.

A. O. Williams, Jr., USA

Ballistics, Detonics (Explosions)

(See also Rev. 692)

796. M. L. Médard, "Experimental study of the specific energy and the detonation velocity of explosives containing aluminum (Étude expérimentale du travail spécifique et de la vitesse de détonation des explosifs renfermant l'aluminium)," *Mémor. Artill. fr.*, 1948, vol. 22, no. 3, pp. 595–611.

The author gives the results of many experiments which seem to indicate, within limits, that the addition of aluminum to many explosives will lead to an increase in the total energy released during the explosion. The energy increase is generally not more than 25 per cent. The greatest percentage increase in energy released occurs when the aluminum constitutes about 15 per cent by weight of the explosive mixture. Benjamin Epstein, USA

797. H. Jones and A. R. Miller, "The detonation of solid explosives; the equilibrium conditions in the detonation wave-front and the adiabatic expansion of the products of detonation," *Proc. roy. Soc. Lond. Ser. A.*, Nov. 9, 1948, vol. 194, pp. 480–507.

Assuming chemical and thermal equilibrium to be maintained in the detonation wave front, and using an equation of state in the form of a virial expansion in terms of pressure, the velocity of detonation of TNT is determined as a function of the loading density. It is assumed that the virial coefficients are constant, and their values are determined to give agreement with the measured values of the detonation velocity for loading densities less than 1.5 g per cm^3. The pressure in the detonation wave front is found to be of the order of 2×10^{11} dynes per cm^3 for a loading density of 1.5 g per cm^3.

With the equation of state adopted in this paper it is found that at a high loading density only negligibly small amounts of hydrogen and carbon monoxide are present in the detonation wave front. It is shown that these gases do, however, develop rapidly during the initial stages of the adiabatic expansion. The chemical composition of the gases and the external work done during the adiabatic expansion from the detonation state are calculated. It is shown that the large amount of chemical energy released in the early stages of the expansion is to be correlated with the high effective value of the exponent of the adiabatic in this region, and this is due to the dominant role of the repulsive forces between the molecules of the tightly compressed gases during the early stages of the expansion. Compared with the results for a high loading density, there is considerably more carbon monoxide and less carbon dioxide and a substantial rise in the total number of moles of gas produced per mole of explosive. The chemical energy released per gram of explosive is less for a loading density of 1.0 g per cm^3 than for a loading density of 1.5 g per cm^3, and the external work done is also less in the former than in the latter case.

The amounts of ammonia and of hydrocyanic acid in chemical equilibrium with the other gases are determined and they are found to be negligibly small. It is concluded that these gases, observed in experiments, are probably formed by catalytic action with the bomb fragments during the cooling period after the adiabatic expansion has been completed. The calculations have been compared with the available experimental data and are in reasonable agreement with them. An explanation is suggested for the observed difference in the composition of the gaseous products of the detonation of TNT, initiated at a given loading density, with detonators of different power.

Stuart R. Brinkley, Jr., USA

Soil Mechanics, Seepage

(See also Rev. 711)

798. A. Coüard, "The elastic stability of circular foundations (La stabilité élastique des fondations circulaires)," *Génie civ.*, Jan. 15, 1949, vol. 126, pp. 27–28.

A paper by Ferrandon on the "Elastic stability of circular foundations" [*Génie Civ.*, Sept. 1, 1942] is discussed. A simplified theory has been developed to determine the soil pressure in various depths with respect to the surface loads. The results are compared with values reported by Caquot, Buisman and Terzaghi and seem to check them satisfactorily.

R. K. Bernhard, USA

799. E. De Beer, "Correlation between the results of cell-tests and compression tests" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 173–184.

Undisturbed and remolded samples of various saturated clays were tested by the author, by simple compression and by cell tests wherein a sample is subjected to a certain number of vertical loads for each of which the minimum lateral pressure required to maintain equilibrium is determined.

The higher strengths obtained at failure in compression tests and the appreciable apparent angles of friction obtained in cell tests at practically constant water content are taken to indicate the presence of a "structural resistance" under large deformations.

Values from both tests at small strains could be related to the natural vertical stresses and shearing resistances.

Edward S. Barber, USA

800. Donald M. Burmister, "A method for estimating the load-settlement characteristics and bearing value of clays and clay-soils from unconfined compression and tri-axial compression tests" (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 18–22.

Consideration is given to the relationship between the axial deformation of a laboratory compression sample and the settlement of a foundation resting on a saturated clay stratum, from which the sample has been extracted in an undisturbed state.

The relationship used is that given in standard elastic theory, and a test is quoted which shows good agreement between load-settlement observations and the settlements as calculated from the compression-test results. Based on the fact that ultimate failure of a foundation on clay takes place when the applied pressure is approximately three times the compression strength of the clay (as measured under conditions of no water-content change), it is inferred that strain in a compression sample is roughly equal to the settlement of the foundation divided by four times its radius or half width.

A. W. Skempton, England

801. J. Jáky, "Stability of earthworks in the plastic state, Part II (Sur la stabilité des masses de terre complètement plastiques)," *Publ. tech. Univ. Budapest* (*Müegyetemi Közl.*), 1948, no. 1, pp. 34–56.

This paper is the continuation of the author's previous study of the stability of earthworks in the plastic state [see Rev. 852, May 1948]. Here he deals with the special stress conditions of the plastic state.

At first he arrives at a general equation on the basis of which he reviews Prandtl's solution and rectifies by calculation the evaluation of Jürgenson's squeezing test. It is proved that the distribution of vertical stresses under squeezing plates is trapezoidal. A relation is shown between slenderness ratio and compressive strength of test specimen. Stress distribution is discussed in the state of triaxial compression, the role of cohesion being evaluated from the results of actual experiments.

Chapter 9 deals with the case of shear failure of subsoil occurring under high dikes and embankments. The critical height of embankments and also the radius of sliding surface are determined and illustrated by numerical examples. The shape of the theoretical slope is fixed. The question of stress distribution is then studied with the use of polar coordinates. The low of radial stress distribution and a new solution for the stress distribution under strip load are developed.

Ch. Széchy, Hungary

802. Gayle McFadden and Thomas B. Pringle, O. J. Porter, T. A. Middlebrooks, G. E. Bertram, William H. Jervis, Joseph B. Eustis, Ralph Hansen, John M. Griffith, J. F. Redus, C. R. Foster, W. K. Boyd, and W. J. Turnbull, "Development of CBR flexible pavement design method for airfields: a symposium," *Proc. Amer. Soc. civ. Engrs.*, Jan. 1949, vol. 75, pp. 4–104.

This is a collection of eleven papers on the application of the California bearing-ratio test to the design of airport flexible pavements. The Corps of Engineers of the U. S. Army adopted the CBR method at the beginning of World War II for the design of airports. The CBR curves available at that time were for wheel loads up to approximately 12,000 lb. The curves were extrapolated to 60,000 lb and a test program set up to determine whether or not this procedure was justified. Reported in this symposium are the results of tests on three major test sections in different parts of the country. Included also are surface-behavior tests and wheel-load tests at nine different airfields.

On the basis of these data, design curves were constructed for single and very heavy multiple-wheel assemblies. The results indicate in general that the CBR penetration tests and design curves yield very reliable results, but that a satisfactory method of preparing laboratory samples has yet to be developed.

Eben Vey, USA

803. A. C. Benkelman and F. R. Olmstead, "A cooperative study of structural design of nonrigid pavements," *Public Rds.*, Dec. 1947, vol. 25, pp. 21–29.

This article is an introduction to a co-operative investigation of the structural design of nonrigid pavements. The participating agencies are the Highway Research Board, the Asphalt Institute, and the Public Roads Administration.

The principal objectives of the investigation include development of the load-supporting values of nonrigid pavements by full-scale field tests, correlation of these data with laboratory tests to determine whether the latter can be used alone in the design of pavement thickness, and correlation of the data with in-place determinations of various values of the base-course and subgrade components.

This preliminary progress report provides a description of the investigation, its purposes, and methods of procedure and will serve as a background for the articles to come.

The present discussion is concerned primarily with a detailed description of the project and with the construction and testing of experimental sections of pavement. In the course of the investigation such tests as the North Dakota cone test, the California bearing-ratio test, and the triaxial-compression test must be made on certain of the component materials of the pavements.

Rollie G. Fehrman, USA

804. **E. A. Willis, "Experimental soil-cement base course in South Carolina,"** *Public Rds.*, Sept. 1947, vol. 25, pp. 9–19.

This report describes the construction of an experimental road in South Carolina and presents results of performance under traffic for an eight-year period. Twenty-two sections of soil-cement base course were constructed, using thicknesses of 4, 6 and 8 in. and cement contents ranging from 3 to 11 per cent. Two sections were built with stone screenings and crushed stone added to the soil but the cement was omitted.

A 3 per cent cement content resulted in an unsatisfactory base course. There was a definite trend toward better performance with increasing cement content. Emulsion curing was superior to tar curing. The effects of cement on the physical characteristics of the soil are discussed.

Harry A. Williams, USA

805. **A. P. Voshchinin, "Design of homogeneous earth dams built on pervious foundations,"** (in Russian), *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*), Nov.-Dec. 1948, vol. 12, pp. 761–768.

The paper presents a mathematical analysis of two-dimensional seepage through a homogeneous earth dam provided with a rock toe and built on a pervious foundation of the same permeability as the dam. The pervious foundation is underlaid by an impervious material.

The solution is obtained in terms of elliptic and hyperbolic functions by means of conformal representation by the method of Joukovsky. Mathematical difficulties require two modifications of the actual boundary conditions: the upper surface of the foundation upstream of the dam is taken at the water level, and the straight horizontal boundary of the impervious layer is replaced by a curved one. The error introduced by these changes is claimed to be small when the thickness of the pervious layer is several times greater than the head. Two numerical examples are solved.

A. Hrennikoff, USA

806. **A. E. Cummings, G. O. Kerkhoff, and R. B. Peck, "Effect of driving piles into soft clay,"** *Proc. Amer. Soc. civ. Engrs.*, Dec. 1948, vol. 74, pp. 1553–1563.

The present paper is a valuable contribution to the important problem of the influence of pile driving into clay grounds, based upon field and laboratory tests made in Detroit. In soil mechanics it is generally supposed that pile driving causes a disturbance of clay grounds which can involve important settlements of the ground surface.

The authors studied the driving of piles into the soft blue glacial lake clay which forms the underground of Detroit in the River Rouge area. The local disturbances around the piles, as well as the general changes produced in the whole mass in relation to possible settlements of the soil surface, were investigated.

The results of these studies showed that only a local disturbance is produced (limited to a few inches from the piles), and the reduced resistance of the surrounding clay was recovered with time. The expulsion of capillary water is only local and no migration of moisture from the whole mass can be established. The conclusion that can be drawn is that the main volume of clay mass gives no sign of a decrease of its resistance and consequently of general settlement of the ground.

Aurel A. Beleș, Rumania

807. **Gregory P. Tschebotarioff, "Determination from bending strain measurements of the distribution of lateral earth pressures against model flexible bulkheads,"** *Géotechnique Lond.*, Dec. 1948, vol. 1, pp. 98–111.

This paper presents the instrument readings and details of calculation for a typical test-stage representative of the large-scale model earth-pressure tests being carried out at Princeton University. Strains in a $^1/_4$-in. thick anchored steel bulkhead 8 ft high by 5 ft wide were determined by SR-4 electrical strain gages in three vertical rows of 35 points each. At each point there were two gages on opposite sides of the bulkhead. Each row was waterproofed by being covered with a vaseline-filled Koroseal tube. Calibration tests were made to correct for the added stiffness due to the gage assembly.

Defective insulation or volume changes of the gage cement caused some erratic readings which were discarded. Averaging three rows helped to minimize errors in balancing the strain indicator. Direct and reversed readings were taken and averaged to eliminate zero shift. Reading unstressed gages at the top of the bulkhead permitted corrections for strain shift taking place in the indicator between readings before and after loading.

The corrected average strains were multiplied by the elastic modulus to give the stress, then by the section modulus to give moment, which was differentiated once to give shear, and again to give load. The fact that the shear curve must be zero at maximum moment and have the same slope on both sides of the anchor, and that the shear areas must equal differences in moment were used as controls on the differentiation. Finally, check moments were computed from the adjusted pressure curve. By means of the moment-area method, deflections were calculated and found to check deflections measured with micrometer dials along two vertical rows. The high precision of measurement indicated by these checks is attributed to the use of a large number of strain gages.

Edward S. Barber, USA

808. **R. Haefeli and W. Schaad, "Time effect in connection with consolidation tests"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 3, pp. 23–29.

The authors have made consolidation tests on a kaolinitic clay, in which the samples were left under constant pressure for three years. They find that these tests confirm Buisman's hypothesis that the compression after an initial period of consolidation due to the dissipation of hydrodynamic excess pressures in the pore water continues at a rate directly proportional to the logarithm of time.

This law cannot hold for extremely large time intervals, but no deviation was observed during the three-year test.

A. W. Skempton, England

809. **L. Casagrande, "Electro-osmosis"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 218–223.

Size-distribution curves, liquid limits, plastic limits and permeability coefficients were determined in the laboratory for nine different soil samples. The quantities of water moved and the water-content variation between electrodes were measured for various voltages applied to the samples. The electro-osmotic pressure head was also measured for these voltages and the values obtained were shown to compare favorably with the Helmholtz theoretical values.

The author discusses the energy consumption in the osmotic

process and indicates that from his measurements on natural soil, using ordinary tap water, the current per cm^3 of soil seems to depend mainly on the grain size. Apparently no tests were made using water of varying salinity.

From the test data presented the author concludes that the flow induced by electro-osmosis may be represented by a law similar to Darcy's law and that the quantity depends primarily on the porosity and the ζ potential. He further implies that this flow in clays takes place through fissures rather than the individual pores, and that the process of electro-osmosis causes a laminated structure to develop, which is similar in appearance to certain natural deposits. Eben Vey, USA

Geophysics, Meteorology, Oceanography

(See also Rev. 794)

810. R. Frost, "Atmospheric turbulence," *Quart. J. roy. met. Soc.*, July-Oct. 1948, vol. 74, pp. 316–338.

The author assumes, as a working hypothesis, that the coefficient of eddy diffusion in the atmosphere K is given by a power of the height above the ground $K = maz^{T-m}$, the exponent of the power being a function of the stability only. According to some experiments [W. G. Swinbank, Cardington, 1943-45] m is a linear function of the temperature difference ΔT between 400 ft and 5 ft, varying from 0.145 for $\Delta T = -4$ F to 0.77 for $\Delta T = +12$ F. The parameter a is equal to $z_0^{2m}V_h h^{-m}$ where V_h is the wind velocity measured at the standard height h, and z_0 a length characteristic of the degree of roughness of the surface.

With these assumptions the author gives a quantitative explanation of: (1) the variation of wind with height from the surface to a height of a few kilometers, (2) the diurnal variation of the wind speed and direction at different heights, and (3) the observed skew frequency distribution of the angle of veer between the surface wind and the geostrophic wind over the sea.

J. Kampé de Fériet, France

811. H. Bondi and R. A. Lyttleton, "On the dynamical theory of the rotation of the earth. I. The secular retardation of the core," *Proc. Camb. phil. Soc.*, July 1948, vol. 44, pp. 345–359.

The authors consider only the tidal friction couple acting on the outer shell and the motion of a viscous core differing from uniform rigid body rotation. The liquid is supposed to be contained in a sphere of radius a rotating with angular velocity $n + kt$ (n is const, k is a const <0, $|k| \ll n^2$). Two equations of fourth order then give the stream function ψ in a meridian plane and the velocity about the axis $w = \Omega/r$. These follow from the general equations for any axially symmetric motion. It is assumed that in the case of the earth ψ and $\Omega = r^2n + kr^2t + \psi(r, z)$ are small quantities (r, z are cylindrical coordinates). Then these quantities will satisfy two linear equations, which in the case of an established motion become

$$\nu\left(\frac{\partial^2}{\partial z^2}+\frac{\partial^2}{\partial r^2}-\frac{1}{r}\frac{\partial}{\partial r}\right)\chi + 2n\frac{\partial\psi}{\partial r} = kr^2,$$

$$\nu\left(\frac{\partial^2}{\partial z^2}+\frac{\partial^2}{\partial r^2}-\frac{1}{r}\frac{\partial}{\partial r}\right)^2\psi - 2n\frac{\partial\chi}{\partial z} = 0.$$

The solutions are given under the boundary conditions $R = a$ (R, θ being polar coordinates), $\psi = \chi = 0$, $\partial\psi/\partial R = 0$, for an interior region $a - R \gg l$ and for a boundary layer of depth l, where the viscosity is of importance. The core, on the whole, always rotates slightly faster than the shell. The circulation in meridian planes consists of a flow toward the equatorial plane in the interior and in the opposite direction in the boundary layer. The relative motion of a liquid core will not have any considerable influence on the action of the tidal friction couple, as if the earth were regarded as a rigid body. The corresponding two-dimensional problem is also treated.

Courtesy of Mathematical Reviews W. Jardetzky, USA

Lubrication; Bearings; Wear

(See Revs. 695, 752)

Marine Engineering Problems

(See also Rev. 703)

812. James E. Kiernan, "A method for the determination of a ship's stability at sea," *Trans. Soc. nav. Archit. mar. Engrs.*, 1948, vol. 9, 5 pp. (reviewed from advance copy).

This paper describes a new method by which the stability curve (righting moment versus angle of heel) for a ship can be determined without knowledge of the loading conditions of the vessel. For application the following data are required: the so-called cross curves of stability, the ship's displacement, the natural rolling period and the angle of heel, if any. The first can be obtained from the geometrical lines of the vessel, the second from draft gages and the last two by available or procurable means. The natural rolling period is difficult to obtain at sea, but according to the paper, can be obtained by statistical analysis of roll-recorder data.

Experimental data obtained on a 20-ft model of a large vessel indicate that the new method produces results which are in close agreement with the results of older methods. This method is an interesting new approach and may have practical value in keeping a running check on the stability conditions of a vessel while it is in service. Karl E. Schoenherr, USA

813. C. J. Wilson, "Analysis of standardization trial results for USS LSM 458 equipped with Kirsten-Boeing cycloidal propellers," *David Taylor Model Basin Rep.*, no. 678, Sept. 1948, pp. 1-15.

Cycloidal propellers are of considerable interest to naval architects because of the great maneuverability which they give to a ship. However, their construction is complex and therefore expensive, and there has been little experience with them. This report answers the question of relative propulsive efficiency in one special case by comparing an LSM equipped with regular propellers with one propelled by Kirsten-Boeing cycloidal propellers. Full-scale standardization trials indicate that both methods of propulsion have roughly the same efficiency. F. E. Reed, USA